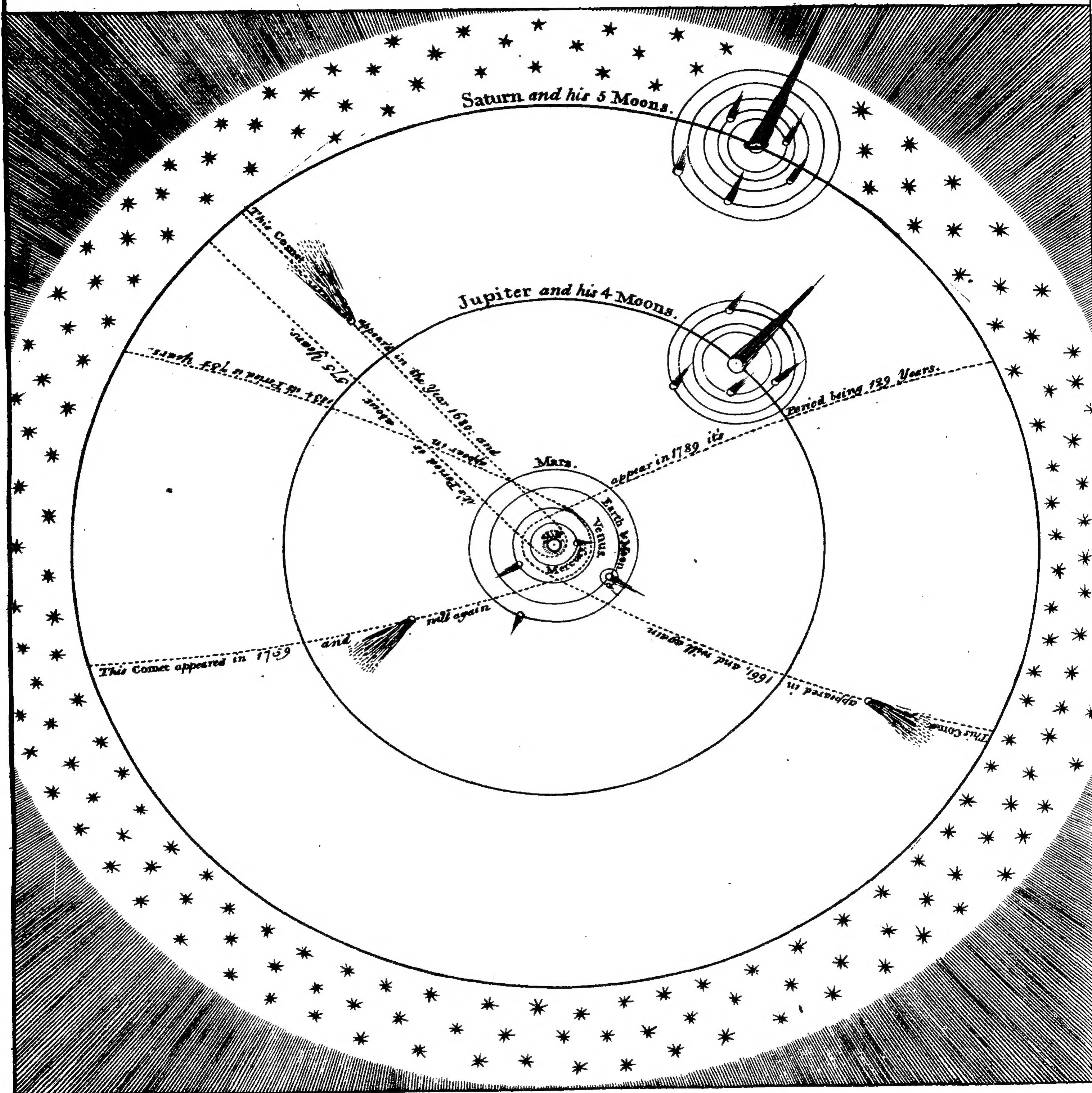
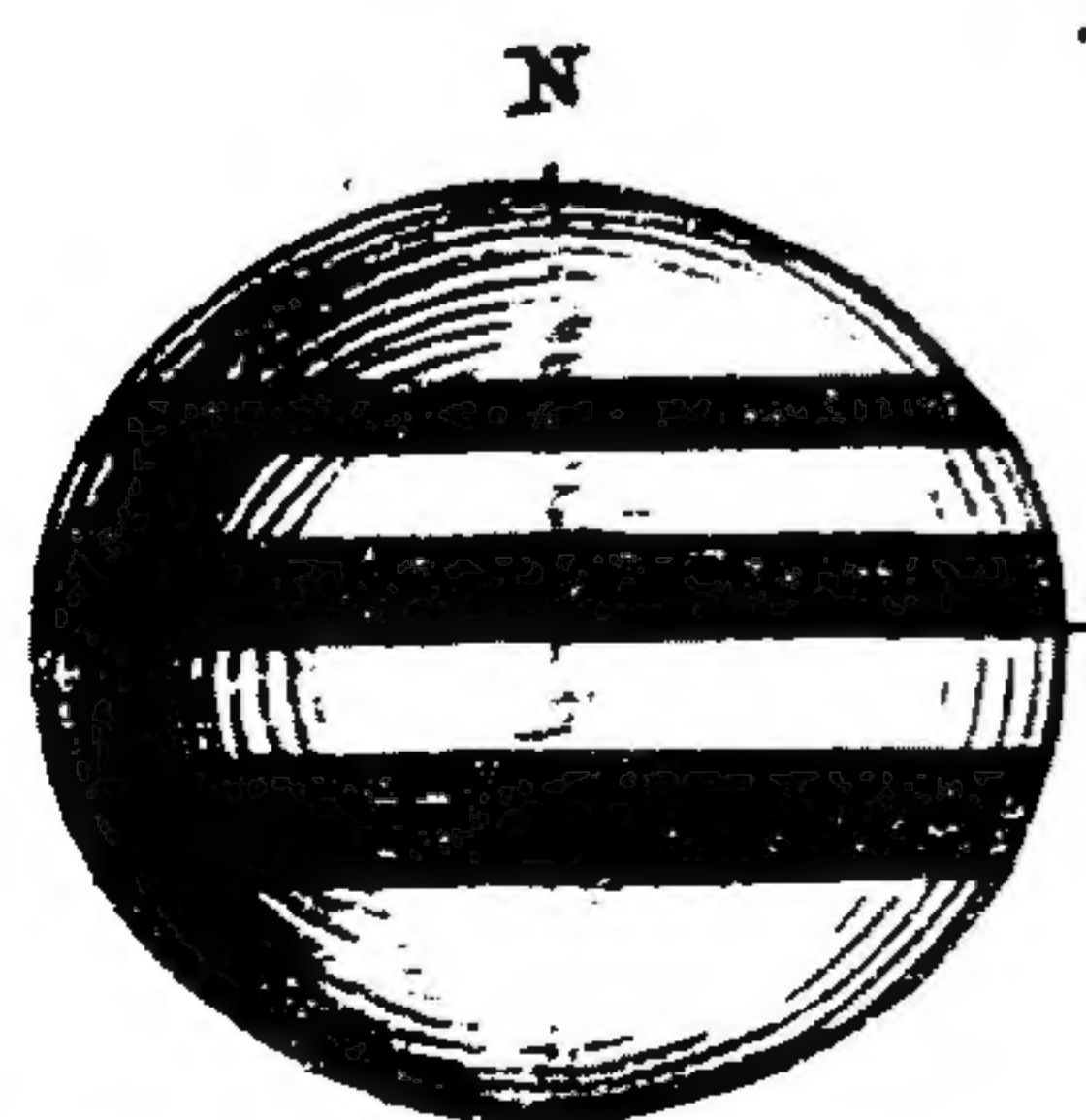


# The COPERNICAN or TRUE SYSTEM of the UNIVERSE:

*exhibiting the Orbits of the PLANETS according to their mean Distances from the SUN.*



The PLANETS in Proportion to each other with the Inclinations of their AXES, &c.



JUPITER and his Belts.

MARS.



EARTH.

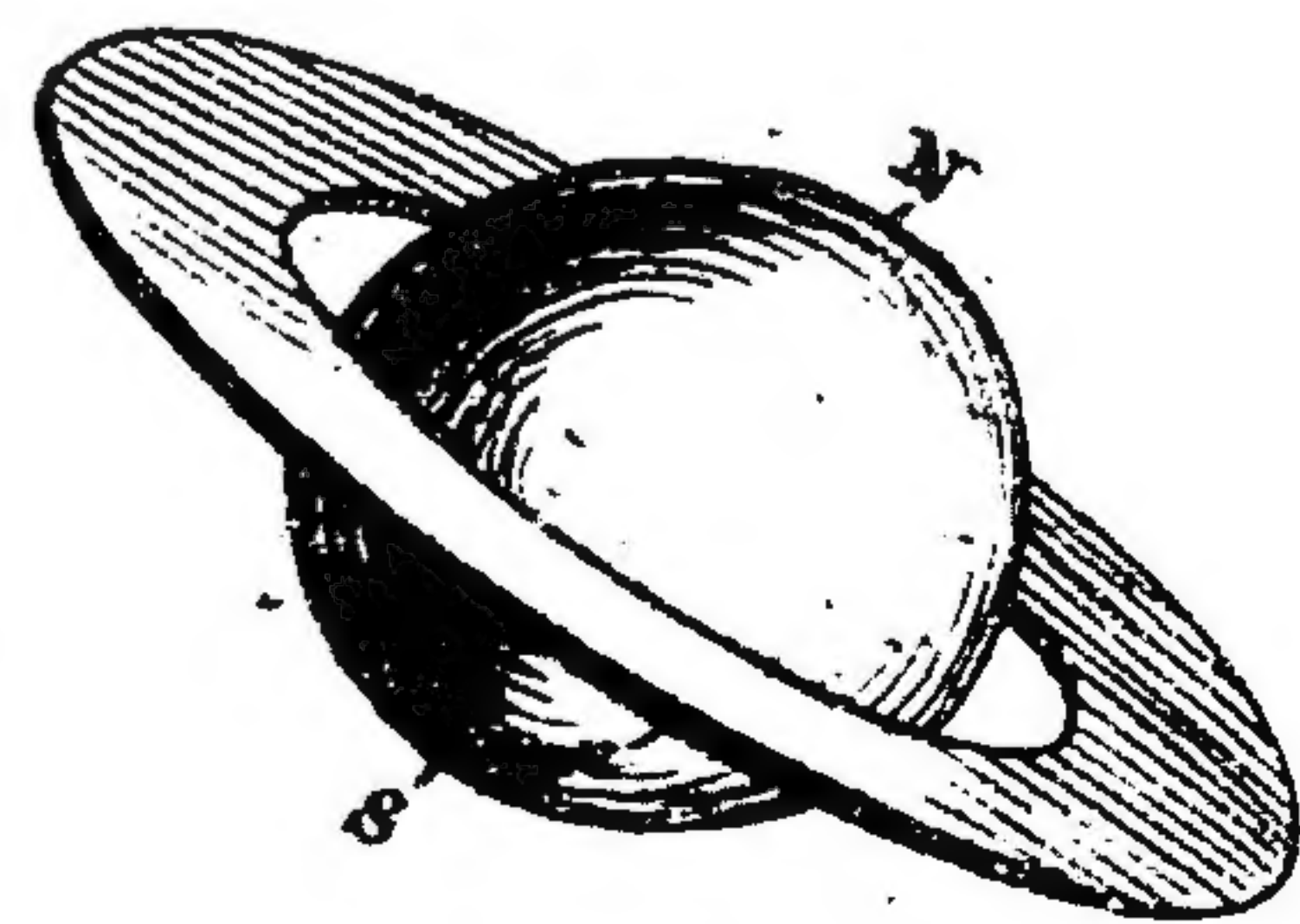
MOON.



VENUS.



MERCURY.



SATURN and his Ring.

*Note: The Sun is about 10 inches in Diameter, according to the above Proportion of the Planets.*



# VIEW of the HEAVENS:

Being a Short, but Comprehensive

S Y S T E M

O F

## MODERN ASTRONOMY.

EXHIBITING,

- |   |   |
|---|---|
| <p>I. The <i>Number, Order, Distances, Magnitudes, and Periods</i> of all the <i>Planets</i> and their several <i>Moons</i>, composing our <i>System</i>, which the <i>Learning</i> of the present Age esteems as so many <i>Worlds</i> full of <i>Inhabitants</i>.</p> <p>II. The <i>Length</i> of the <i>Day</i> and <i>Year</i>, with the <i>Variety</i> of the <i>Seasons</i> in each <i>Planet</i>; and also the <i>Phænomena</i> of the <i>Heavens</i> to the <i>Inhabitants</i> thereof.</p> <p>III. Some Account of the <i>Comets</i>, their <i>Number, Periods, and Appearances</i>; and also the <i>Directions</i> of their <i>Fiery Trains</i> thro' the <i>Heavens</i>; with probable <i>Conjectures</i> of the <i>Uses</i> of those <i>amazing Bodies</i>.</p> | <p>IV. The <i>Number, Magnitude, and Distances</i> of the <i>Fix'd Stars</i>; with their <i>Divisions</i> into <i>Signs, Catalogues, and Constellations</i>.</p> <p>V. The <i>direct and retrograde Motions</i> of all the <i>Planets</i>; as also, the Reason why they sometimes appear <i>stationary</i>, or <i>not to move at all</i>.</p> <p>VI. The <i>Nature and Causes</i> of <i>Eclipses</i>, both of the <i>Sun</i> and <i>Moon</i>; with an easy and expeditious <i>Method</i> of calculating the <i>Eclipses</i>, which will happen in any <i>Year</i>.</p> <p>VII. The <i>Description and Use</i> of a curious <i>Astronomical Clock</i>, which will shew the <i>Hour of the Night</i> by the <i>Stars</i>.</p> |
|---|---|

TO WHICH IS ADDED,

## The Use of the CÆLESTIAL GLOBE;

WITH

Its *Application* to a Number of very interesting *Problems*. Concluding with some curious *Phænomena* upon the *Sun* and *Moon* exhibited in a *darkened Room*; and a few *select Paradoxes*, intended to excite the Attention of the Learner.

The whole *illustrated* with *Copper-plates* of the *System*, the *Sun*, *Moon*, *Eclipses*, &c. and dispos'd in so *easy and natural* a Manner, as to be understood in a *few Days*.

---

By the Rev. Mr. <sup>Richard</sup> TURNER, late of *Magdalen-Hall, Oxford*,  
 Author of *The View of the Earth;—Plain Trigonometry Render'd Easy and Familiar;*  
*—System of Gauging;—and Chronologer Perpetual.*

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—The *WORLDS* were framed by the *WORD* of *GOD*. PAUL.

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L O N D O N:

Printed for S. CROWDER, in Pater-noster-Row; and S. GAMIDGE,  
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T O  
THE RIGHT HONOURABLE  
GEORGE HENRY EARL OF LICHFIELD,  
CHANCELLOR;

TO THE REVEREND  
THE VICE-CHANCELLOR;

AND TO THE  
HEADS OF HOUSES,  
AND  
MEMBERS OF CONVOCATION,  
IN THE  
UNIVERSITY OF OXFORD,

THIS  
COMPENDIUM OF ASTRONOMY,

(Drawn up with a View to render the first Rudiments of so  
illustrious and useful a Science more easy and practicable to  
the Minds of Youth, and particularly of those who receive  
their Education in that antient and venerable Seat of Learning,)

I S  
WITH THE MOST PROFOUND HUMILITY ADDRESSED,  
AND  
THEIR PROTECTION AND FAVOUR MOST RESPECTFULLY CRAVED,

By THE AUTHOR.



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A S H O R T  
S Y S T E M  
O F  
M O D E R N A S T R O N O M Y.

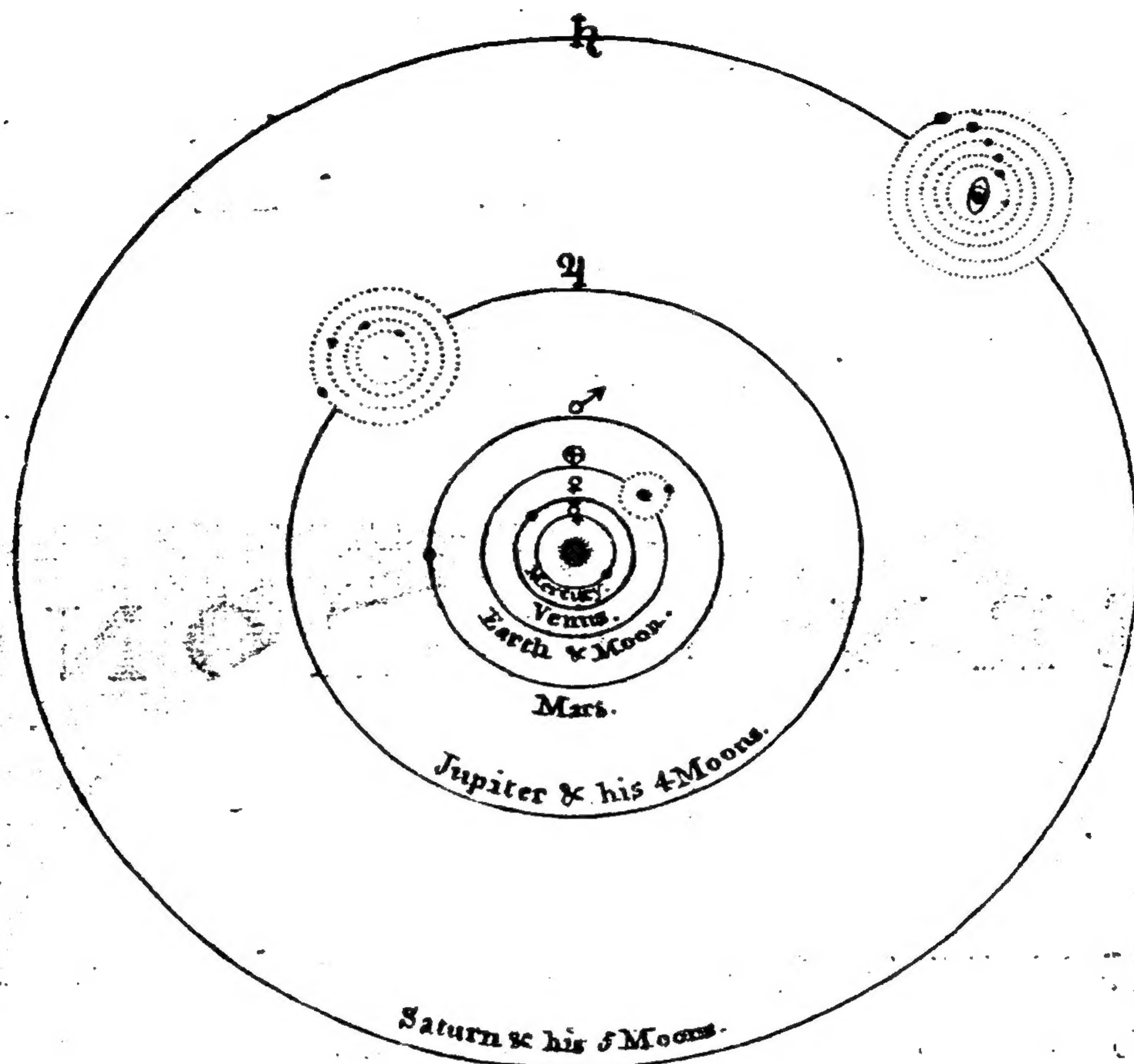
**A**STRONOMY is that Part of *Learning*, which contemplates the *Number, Order, Distances, Magnitudes, Periods, and Appearances* of the Heavenly Bodies; as the *Sun, Moon, Planets, Comets, and Stars*:—And is a *Knowledge*, which contributes not only to the Enlargement of our *Ideas* of the *Immensify, Magnificence, and transcendent Grandeur* of God; but also affords the *sublimest and most satisfactory Entertainment* to the *Understanding and Mind* of Man.

When we look up to the *Heavens*, which Way soever we turn our Eyes, some of these wonderful *Luminaries* present themselves to our View: And, as God hath told us—that *He ordained them for Signs and for Seasons;—for Days and for Years*;—it is certainly our *Duty* to observe their stated Periods, that They may answer the great End—so wise—so beneficent a *Providence* intended they should.

ASTRONOMERS, in Consequence of this divine Appointment, to determine the *Times and Seasons*,—have found, by their repeated Observations, that several Bodies move round the *Sun*: And, as they appear through the *Telescope* to be large *Globes* of *Earth*, like our own, (and, that our *Earth*, viewed from them, would appear as they do to us) have justly concluded them to be *Worlds* enlighten'd and warm'd by the *Sun*, as ours is, and inhabited by various *Species* of *Beings*; though perhaps very different from those on our Globe; but properly form'd and constituted, for the Situation God hath placed them in there.



The *Names* of the several *Globes* or *Planets*, moving round the *Sun*, and composing our *System*, together in the Order in which they revolve, are—— First, *Mercury* (☿)\*—next, *Venus* (♀)—the Third, our *Earth* (⊕) with the *Moon* (☾)—the Fourth, *Mars* (♂)—the Fifth, *Jupiter* (♃) and his 4 *Moons*—the Sixth, *Saturn* (♄) and his 5 *Moons*: All which are represented at their proper Distances, with respect to each other, from the *Sun*, in the *Scheme* at the Beginning of the Book; or in This here delineated.



What Kind of *System* was received in the first Ages of the World, has not been transmitted to us; but this *System* we find taught and profess'd by *Pythagoras*, a learned *Greek* Philosopher, about 500 Years before *Christ*. After his Time, it lay dormant, till *Nicholas Copernicus*, a *Clergyman* in *Prussia*, reviv'd it about the latter End of the 15th Century; and now it has gain'd the Esteem of the Learned World†.

In this *System* we see, as in a *Glass*, the Beauties and Harmony of the *Universe* display'd; for here are neither *solid Orbs* nor *Chrystaline Heavens* to carry the Planets round, as vainly imagined by *Ptolemy* and Others; but every Thing appears in a most *simple, rational, and demonstrable* Order.

It is made up and adorn'd with 17 *Bodies*, which we shall immediately proceed to speak of, and in the *Order* and *Situation* they are found in the *System* itself..

\* The Characters placed with the Names of the Planets, are, for Brevity's sake, commonly used by Astronomers, instead of the Words at Length; as ☿ for *Mercury*; ♀ for *Venus*, &c.

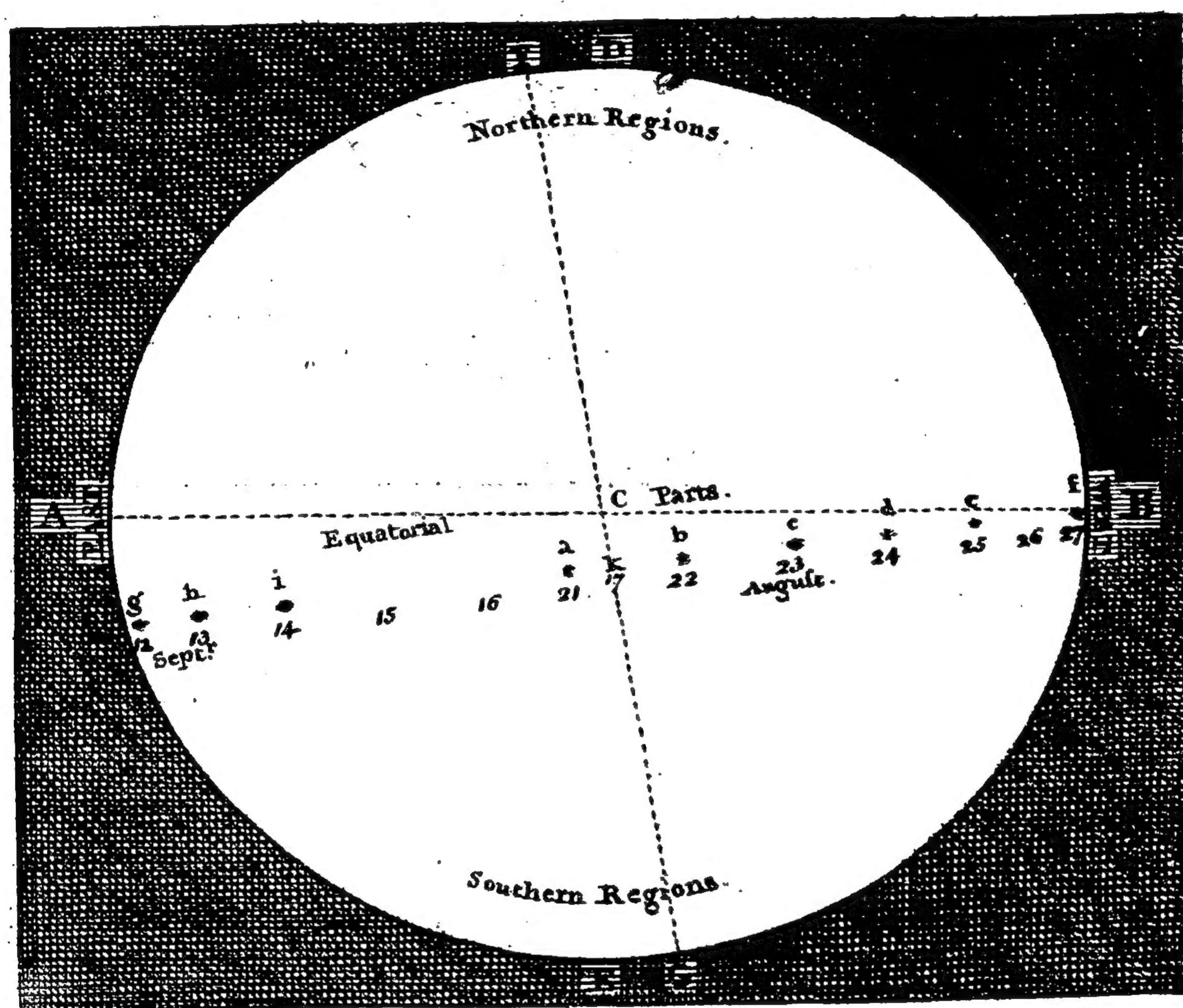
† Most of the Antients (not acquainted with Mathematical Learning) took it for granted that the *Earth stood still*, and the *Sun moved*, because it appear'd to do so. Accordingly, their most famous *System*, published by *Ptolemy*, an *Egyptian Astronomer*, about 138 Years before *Christ*, supposes the *Earth* immoveably fixed in the Center of the Universe, and the 7 Planets, viz. *Moon, Mercury, Venus, the Sun, Mars, Jupiter, and Saturn*, to revolve in Circles round it. Beyond these is placed the Firmament of the *fixed Stars*; then two *Chrystaline Spheres*: All which were included in, and received Motion from the *Primum Mobile*, which constantly carried all those vast and solid Orbs about the *Earth* in 24 Hours, from East to West.—But this *System* being found to be too much accommodated to *Sense* to stand the Test of Art; others were contrived and published at different Times; but all of them being embarrassed with many Difficulties and Absurdities, were embraced by a few; and at last were obliged to give Way to the only true and rational *Solar System*, restored by *Copernicus*, as mentioned above.



# Of the S U N.

**FIRST**, we find the *Sun* in the Center of the *System*, immoveable from thence, having no *circular* Motion in an Orbit, but a *central one* only about his own *Axis*, in the Space of 25 Days and a Quarter, as discover'd by viewing him through a *Telescope*. He is about 800.000 Miles in *Diameter*; is one Million of Times larger than our Earth; and by his Rotation dispenses *Light*, *Heat*, and *Motion*, to all the Planets revolving round him.

By observing the *Sun* through a good Glafs, he generally appears to have one or more *black Spots* on his Body, which come on the *eastern* Side, pass over his Face, and go off on the *western*, in a little more than 13 Days, and in the same Space of Time return again. By these Spots, not only his Rotation on his *Axis* was discovered as above, but also that his *Axis* leans or inclines to the Orbit of the Earth in an Angle of about 82 Degrees. The Places, and Manner in which a large Spot appear'd to pass over the Sun's Disk, in *August* and *September*, 1764, are as here delineated.



On the 21st of *August* the *Spot* was seen at *a*; on the 22d at *b*; the 23d at *c*; 24th at *d*; on the 25th it was at *e*; the 26th not observed; on the 27th it appeared at *f*; on the 28th not observed; on the 29th supposed to be on the *western* Edge. After 13 Days Absence, *i. e.* on Sept. 12th, the *Spot* appeared again on the *eastern* Edge at *g*; on the 13th Day it was at *h*; on the 14th at *i*; the two following Days were cloudy; but on the 17th it was found at *k*; having completed a Revolution.—FG represents the *Axis* of the Motion of the Spot. F the *North-pole*, and G the *South-pole*. ACB is the *Ecliptic*, or Tract opposite the Earth's Orbit. D and E its two Poles. This Spot was about a *thirtieth* Part of the Diameter of the Sun, consequently was near 26.000 Miles in Length; its Breadth was something less.—A Spot, less in Diameter than our Earth, is not visible without a good Glafs\*.

\* These *Solar Spots* do not always remain the same, but sometimes old ones vanish, and afterwards others succeed in their Room; sometimes several small ones gather together and make one large Spot; and sometimes a large Spot is seen to be divided into many small ones. But, notwithstanding these Changes, they all turn round with the Sun (towards the West), in the same time, which is an undeniable Proof they are on his Surface, and not at a Distance from him.

Whilst



Whilst the *Sun* turns thus on its *Axis* in 25 Days and a Quarter, it throws off from itself a fine subtle Matter, which is extended through all Parts of the *System*. This Matter is what constitutes Light; and comes with such Rapidity, that it arrives from the Sun hither in seven or eight Minutes Time. It passes through the Pores of *Glass* and other transparent Bodies, with little or no Resistance; but when it falls upon Bodies it cannot penetrate, it is reflected to the Eye, and so renders them visible. By this Means, we know that the *Planets* are *opaque*, or dark Bodies in themselves, and shine only by this reflected Light; for when the Sun is in such Position that it cannot shine upon that Part of them next us, they become obscure and invisible.

There are *six Primary* or principal *Planets*, and *ten Moons*, which receive their Light from the Sun, viz. *Mercury*, *Venus*, the *Earth* and *Moon*, *Mars*, *Jupiter* and his *four Moons*, *Saturn* and his *five Moons*. Each *Primary Planet* describes a large *Orbit* round the *Sun*, and being placed at different Distances, one beyond the other, make their *Revolutions* in different Periods of Time.

In these *Revolutions* of the *Planets*, there is one thing very remarkable, which is, that they are all made the *same Way*, i. e. from *West* towards the *East*, and opposite the *middle* or *equatorial* Parts of the *Sun*; which caused some *Philosophers* to imagine they were carried about by a *Vortex* or *Whirlpool* of *Æthereal Matter*. But many Observations made on the Heavenly Bodies by the *Moderns*, have sufficiently confuted that Opinion \*.

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\* \* \* If the young *Astronomer* has a Mind to observe the *Spots* upon the Sun; the best Way will be to use a *Refracting Telescope* of about six or eight Feet,—or a *Reflection* one of two or three, with a *fmoaked Glass* placed before the Eye-glass next the Eye, which will take off the glaring Light, and render the Spots visible. By this Method their Appearances may be observed, Day by Day, and the Tract they describe in their Passage over the Sun's Disk easily ascertained.—Or, the Image or Picture of the Sun, with its Spots, may be received into a *dark Room*, through a Telescope of one or two Feet long, (without a *fmoaked Glass*) upon a Piece of white Paper, which may be magnified or diminished, by bringing the Paper nearer or further from the Glass, to the Dimensions you please. This is an innocent and easy Way; but one Inconvenience attends it, which is, that the *Image*, seen upon the Paper, always appears in an *inverted Position*.

\* This will be further considered, when we come to treat of the Motion of Comets.



## Of the Planet MERCURY.

**N**EXT the Sun, at the Distance of 32 Millions of Miles, we find *Mercury* performing his *Revolution* in the Space of 87 Days, 23 Hours, and 13 Minutes.—He is seldom seen with the naked Eye, because of his *Nearness* to the Sun, being never distant (either *before* or *after* him) more than 27 Degrees: And, because the *Heavens*, at the Time *Mercury* is at his greatest Distance from the Sun, are so *illuminated*, there can be no Observation made to discover the *Spots* on his Body, by which his *Rotation* on his *Axis* might be certainly discovered.—The Diameter\* of this Planet is about 2460 Miles; which makes him near 30 Times *less* in Bulk than our *Earth*.

The *Year*†, to the *Inhabitants* of this Planet, (for it is the Opinion of the *Learned*, that the several *Planets* are so many *Worlds*, furnish'd with Beings of different Kinds as our *Earth* is,) is scarcely equal to *one Quarter* of Ours: But as they are almost *three Times* nearer the Sun than we are, his *Face* must consequently appear *three Times* bigger; and his *Light* and *Heat* almost *nine Times* greater than with Us. This Degree of Heat would continually keep our *Waters boiling*, and render it impossible for Us to live; but the Bodies of *Animals* and *Vegetables* there, are, no doubt, properly temper'd to sustain it. They, as well as their *Planet*, may be constructed more *dense*, *firm*, and *compact* than we are here; and may require that very Degree of Heat to support them in Life, which would destroy Beings of our softer *Texture*, and consume them away.

The *Length* of the *Day*, and the *Variety* of the *Seasons* there, is totally *unknown* to our *Astronomers* at present: For they have not been able (by Reason of his *Nearness* to the Sun, and the great Illumination of the *Heavens*, when at his greatest Distance) to discover the *Inclination* of his *Axis*, or the Time he *revolves* about it.

The *People* in this Planet will observe the *Spots* on the *Sun* much plainer than we can, and, consequently, be enabled to discover his *Rotation* on his *Axis*, and the better ascertain what those *Spots* are. As to the rest of the *Planets* above *Mercury*, their Appearance will be much the same as to us at the *Earth*. So that *Venus* and our *Earth*, when in *Opposition* to the Sun, will shine with a *full Face*, and consequently afford a great *Light* to this Planet by Night. But *Mars*, *Jupiter*, and *Saturn* will not give him quite so much as they do us, by Reason of their greater Distance from him.

\* The *Distances* of the *Planets* from Us, and from one another; and also their *Diameters*, are obtained by *Trigonometry*.—An easy Method of making those Calculations, is shewn in my *Treatise* on that Subject.

† The *Revolution* of a Planet *round the Sun*, is called the *Annual* or *Yearly* Motion, because they have all the Alterations of the *Seasons*, and *Varieties* of the *Year*, complete in that *Revolution*.—And the *Rotation* of a Planet *round its Axis*, is called the *Diurnal* or *Daily* Motion; because, by this Means, each part of their Surfaces are carried successively towards and from the Sun, which always illuminates that Half next him, making it *Day*; whilst the other Half remaining in *Darkness*, must constitute its *Night*.

The *Periods* of the *Planets* are determined by observing the Time of their Departure from a fix'd Star, till they arrive to the same Star again.—And the *Diurnal* Rotation round their *Axes* is discovered by *Spots* seen with the *Telescope* upon their Disks, which *Spots* appear to pass over their Faces in a certain Space of Time, and after being absent the same Time, return again, and pass over their Disks as before.



## Of the Planet VENUS.

**N**EXT beyond *Mercury* is the glittering Planet *Venus*: She makes her periodical Revolution in 224 Days, 16 Hours, and 49 Minutes, at the Distance of 59 Millions of Miles from the Sun. She is observed to turn upon her *Axis* in 23 Hours, and her Diameter is about 7906 Miles, which is nearly equal to our Earth.

*This Planet*, as well as *Mercury*, can never be seen at *Midnight*; but is visible only three or four Hours in the *Morning* and *Evening*, according as she is *before* or *after* the Sun. When she is in that Part of her Orbit *west* of the Sun, she rises in the *Morning* before him, and is called the *Morning-star*. When she is on the *east* Side of the Sun, she sets in the *Evening* after him, and is then the *Evening-star*.

Since these two Planets, *Venus* and *Mercury*, always accompany the Sun, (and are never farther from him than, the latter about 27 Degrees, and the former 47,) *Astronomers* well know, that the Earth's Orb must circumscribe their Orbits; and that they revolve about the Sun in Circles much *nearer* than we are: Hence it is, they are never found one-twelfth or one-eighth Part of a whole Circle from him; *which* they would be, if the *Earth* was in the *Center* of the *System*, and they went round us\*.

To the *Inhabitants* of this Planet, the *Sun* will appear almost *twice as big* as he does to us: His Face, and consequently his *Light* and *Heat*, must be almost *four* Times greater. The *Year* in that Planet is about *two-thirds* of our Year, and the Length of the *Day* 23 Hours.

They who observe the Heavens there, will see *four Planets* above them; viz. the *Earth*, *Mars*, *Jupiter*, and *Saturn*; and *one* below, which is *Mercury*. When our *Earth* is in *Opposition* to the Sun, it will appear to shine (in the Night) there with a full Face, and very bright. The *Moon* will always seem to wait upon the Earth, and never appear more than half a Degree (or two Hands Breadth) from it. *Mercury* will accompany the Sun, and be seen as a *Morning* and *Evening* Star by Turns, just as *Venus* does to us.

Some *Astronomers* think, they have observed a small *Moon* belonging to this Planet, about one-fourth as big as *Venus*: And the Reason we don't frequently see it, is owing, perhaps, to the Unfitness of its Surface to reflect the Light so far. And indeed, if this Planet has no *Moon*, I can't conceive how the *Inhabitants* will distinguish their Times, since the *Inclination* of its *Axis* is very little, if any, and the Sun always in their *Equator*; consequently there must be continually the same Seasons of *equal Day* and *equal Night* all round her Orbit.

\* *Venus* and *Mercury* appearing through the Telescope, sometimes *horn'd*, and sometimes *gibbous*, like the Moon, is another Proof of their going round the Sun in Orbits within the Earth's Orbit; and for this Reason they are called *inferior Planets*. *Venus* is six Times nearer us at her *inferior Conjunction*, when on this Side the Sun next us, than at her *superior Conjunction*, beyond the Sun. She consequently appears much bigger in the former Situation than in the latter. For though at her *inferior Conjunction* she shews but a small Part of her Disk, and looks through the Telescope like a Moon three Days old; yet, on Account of her Nearness, that small Part contains a greater Area of Light than the whole Disk does, when at her greatest Distance beyond the Sun. In this Situation she has been often seen in the *Day* near the Sun, and been taken, by the common People, for a *New Star*.



## Of the EARTH.

**T**HE *Earth*, on which we live, is one of the Planets; the next beyond *Venus*. She moves round her Orbit at the Distance of 81 Millions of Miles from the Sun, and completes her Revolution in 365 Days, 5 Hours, and 49 Minutes\*. This produces the several Seasons of the Year, *Winter*, *Summer*, *Autumn*, and *Spring*.

Besides the *Annual* or yearly Motion, she has a *Diurnal* one upon her Axis from *West* to *East* in 24 Hours, which makes the Sun and all the heavenly Bodies appear to move round from *East* to *West* in the same Time. This is the Cause of *Day* and *Night*; and of the *rising* and *setting* of all the heavenly Bodies.

If the *Earth* was view'd from the Sun, as she revolves in her Orbit, she would seem to pass (as a small Star) through the Heavens, describing a Circle among the *fixed Stars*. Which Circle *Astronomers* have divided into twelve equal Parts, corresponding to the twelve Months of the Year; and have suppos'd each Part cover'd with an Image, or Picture of some living Creature, and call'd that Space by the Name, or Sign of the Image depicted there.

The Names and Characters of the twelve Signs are,

<i>Aries</i>	<i>Taurus</i>	<i>Gemini</i>	<i>Cancer</i>	<i>Leo</i>	<i>Virgo</i>	<i>Libra</i>	<i>Scorpio</i>	<i>Sagittarius</i>	<i>Capricornus</i>	<i>Aquarius</i>	<i>Pisces</i>
♈	♉	♊	♋	♌	♍	♎	♏	♐	♑	♒	♓
Ram	Bull	Twins	Crab-fish	Lion	Virgin	Ballance	Scorpion	Archer	Sea-goat	Water bearer	Fishes

When the *Earth*, moving round her Orbit, comes opposite to any of these Pictures, she is said to be in that *Sign*, which the Picture expresses. And as the *Earth*, like the rest of the Planets, revolves from *West* to *East*, the *Sun* will appear to have an *Annual* Motion the same Way, and in the same Tract, but still in the opposite Point. For when the *Earth* is in that Part marked *Aries*, or the *Ram*; the *Sun* will be in that Part mark'd *Libra*, or the *Ballance*; and so of any other; as may be seen in the *Earth's* Orbit delineated on the other Side.—This Circle is called the *Ecliptic Line*, because the Planets seldom eclipse each other, unless they appear upon that Line, and in the same Point, and then the nearer may happen to obstruct our View of the other beyond it.

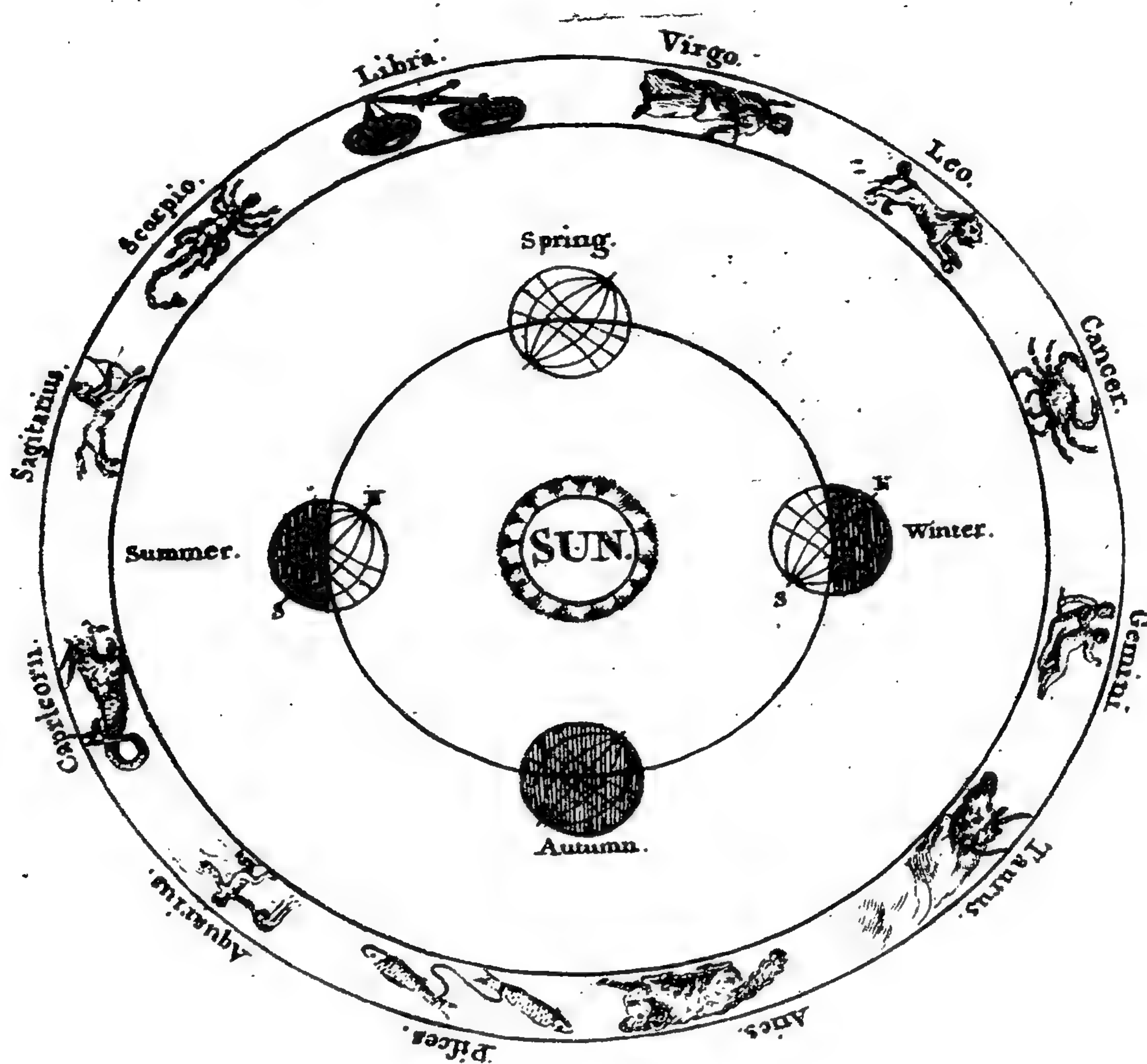
\* The Revolution of the *Earth* in her Orbit, which is the Length of a *Solar Year*, is exactly 365 Days, 5 Hours, and 49 Minutes; but we (to avoid Fractions) account it 365 Days, 6 Hours, which is 11 Minutes too much. These 11 Minutes, in about 134 Years, amount to one whole Day; which Day being retain'd, must make the *Sun* appear to recede one Day back in the Kalendar in that Time. Consequently, the *Vernal Equinox*, which happened about the 21st of March, at the Time of the *Nicene Council*, (in 325,) must, after 134 Years, happen on the 20th, and in 134 Years more, on the 19th, and so on. In our Time, the *Equinox* was gone back to the 10th of March; i. e. 11 Days from the Place it was in before; and would, in Time, have retreated through the whole Kalendar, and thereby have thrown all the *moveable* Feasts into the greatest Confusion.—To remedy this Inconvenience, the Legislative Power, by an Act passed in 1752, threw out the 11 additional Days, by calling the 3d of September the 14th, in Order to bring the *Equinox* to the Place it was at when that Council was held. And, to keep it fix'd there, order'd, that three Days every 400 Years should be omitted, in the following Manner; viz. the Years 1800 and 1900, which should have been *Leap-years*, shall be accounted *common Years*, of 365 Days only. But the Year 2000, and every fourth Hundred Year after that, shall be a *Leap-year* of 366 Days, the intermediate Hundreds only *common Years*. By this Means, our Reckoning will not vary a Day again, in less than 8 or 10000 Years, which is very inconsiderable.

\*\*\* Our Times and Seasons now correspond with those at the Calling of the first *Christian Council*, when the Affairs of the Church were settled by Order of the Emperor *Constantine the Great*, in the Year of *Christ* 325.



If the *Earth* had no *Inclination* of its *Axis* to the Plane of its Orbit, the Sun would ever appear in the *Equinoctial*, making the Days and Nights equal throughout the Year. But by having an *Inclination* from the Perpendicular of  $23\frac{1}{2}$  Degrees, and directing the Poles always to the same Points of the Heavens; hence arises the Division of the *Earth* into *Zones*, as exhibited in my *Geography*, and all the Variety of the Seasons we enjoy; as is clearly expressed in the following Figure.

By this *Inclination*, the Sun is made sometimes to visit the *northern* and *southern* Parts, making them more warm and comfortable; and leaving the equinoctial Parts for a small Time, makes them more cool and fit for Habitation.



When the *Earth* is in *Libra*, the Sun will appear to be in *Aries*. Then begins our *Spring*. The Sun is over the *Equinoctial*, and his Light is diffused equally from Pole to Pole, making the Days and Nights every where equal. This happens the 21<sup>st</sup> of *March*.——When the *Earth* is arrived at *Capricorn*, the Sun is then at *Cancer*. Now the *North-pole* is turn'd not only towards the Sun, but all the northern Parts are much nearer. His Rays now strike us more forcibly; while the *southern* Parts are turn'd from the Sun; and the Pole itself, and the Parts round it, are involved in Darkness. This is the Beginning of *Summer*, falls upon *June* 21<sup>st</sup>, and the Days are at the longest.——From hence, as the *Earth* advances, the Sun begins to leave the northern Parts, till she arrives at *Aries*, where the Sun appears in *Libra*. He is then got over the *Equinoctial* again, and distributes his Light and Heat equally over the Globe from Pole to Pole, making equal Day and Night, as in the Spring. This is the Beginning of *Autumn*, and happens *September* 23<sup>d</sup>.——As the *Earth* goes on, the Days still continue to shorten, till she arrives at *Cancer*, at which Time the Sun will be found in *Capricorn*. Now the *southern* Parts, you see, are turn'd towards the Sun, and strongly illuminated, making their Summer; whilst the *northern* Parts are turn'd from him, and the Pole is involv'd in Darkness, as the *southern* was in the opposite Part of the Orbit. Our Days are now at the shortest; the Sun's Rays fall more oblique and feeble; and *Winter* now begins, *December* 21<sup>st</sup>. Here,



Here it may not be improper to observe that the Orbit of the *Earth* is not perfectly *circular*, but a little *elliptical*: For which Reason, the *Sun* will be nearer the *Earth* at one Time than another; and the *Earth* will move slower and faster\*: Whence it follows, that she will pass over one Half of her Orbit in less Time than the other. For, from *Autumn* September 23d. to *Spring* March 20th. is eight Days less than from *Spring* to *Autumn* again. And so many Days is our *Summer* Half-year longer (when the *Sun* is farther off) than our *Winter* Half (when the *Sun* is nearer) as any one may easily perceive, if he will only count the Days from these Periods in an *Almanack*.

The *Figure* of the *Earth* is that of a *round Ball*, as is evident from the Observations of those who have sailed round it; as also from its *Shadow* being always *round* when it is seen to fall upon the Moon and eclipse her. But the Parts at the *Equator* have been found, by Sir *Isaac Newton*, to be higher than those at the *Poles* by about 34 Miles. And it is very necessary it should be so constructed, else the Waters of the Ocean there, would have been whirled over the Land, by the *Earth's Diurnal Motion*.

The *Circumference* of the *Earth* is supposed to be divided into 360 equal Parts, call'd *Degrees*, and each of these into 60 Parts, call'd *Minutes*. Now our Countryman, Mr. *Norwood*, found by measuring from *London* to *York*, in the Year 1655, that one of those *Degrees* upon the *Earth's* Surface contain'd  $69\frac{1}{2}$  Miles; therefore its *Circumference* must be 25.020 Miles, and its *Diameter* 7964.

The *Earth* is surrounded with a thin vaporous Air, call'd its *Atmosphere*: This reaches every where to the Height of about 46 or 47 Miles; and serves to suspend the *Clouds*, furnish us with *Winds* and *Rains*, and serves to the common Purposes of *Breathing*; it is also the Cause of the Morning and Evening *Twilight*, and all the Brightness and Glory of the Sky.

Every *Planet* is supposed to be surrounded with such an *Atmosphere*, which serves to the same Purposes there, as ours does here†.

\* The common People think that the *Sun* moves, and that the *Earth* stands fixed in the Centre of the Universe; and, when they argue on this Subject, produce those Texts where mention is made of the *Foundation and Pillars of the Earth*; and that it *abideth for ever*.—Also, that the *Sun* *riseth*, *goeth down*, and *hasteth to the Place where he arose*.—That the *Sun* *cometh forth like a Bridegroom out of his Chamber*, and *rejoiceth as a Giant to run his Course*.—That the *Sun* *stood still over Gibeon*; and *went back ten Degrees on Ahaz's Dial*. But all these Expressions are to be understood according to the *Appearance* of Things, not as they are in *Fact*. With the Sacred Writers it was usual, when they spake of the *Sun* or *Earth*, to express themselves according to the *Conceptions* and *Ideas* of the People rather than the real Nature of the System. And even the *Astronomers* themselves, though they know and teach the Contrary, yet in their common Conversation say—the *Sun* *rises*—the *Sun* *sets*—the *Sun* *moves*, &c. For did they alledge the Motion to be in the *Earth*, they would be under a Necessity of explaining themselves every Time they spake to the *Vulgar* on that Head.—But there are many Places in Scripture which clearly assert the *Situation*, *Figure*, &c. of the *Earth*, the *Plurality of Worlds*, *Antipodes*, &c.—As, (1st.) where God is said to *frame the Worlds by his Word*. Now *Worlds* must imply more than one, consequently the *Planets* may be inhabited *Worlds*.—He made the *Round World*, i. e. the *World*, or *Earth* we inhabit must be *globular*.—He hung the *World* upon *Nothing*; i. e. suspended it in the immense *Void*.—He shall subdue *People* under us; i. e. the *Antipodes*.—And *Nations* under our *Feet*; i. e. the *Kingdoms* of the *West*.—The *Wind* goeth towards the *South*, and turneth about to the *North* according to its *Circuit*; this expresseth the *Trade-winds* and *Monsoons*.—And the Rev. Mr. *Kennedy*, in his *Astronomical Chronology*, has proved, from the Writings of *Moses*, that Time commenced at the *Autumnal Equinox*.—That the *Earth* began its *annual Motion*, October 25th at Noon; the *Sun* being then  $10^h 24'$  to the West of *Greenwich*, i. e. over a Meridian passing through the Middle of the vast *Pacifick Ocean*.—That this happened, in Coincidence with a *full Moon*, on the fourth Day of the first Week at Noon, being *Thursday*.—And from the Year 1761 was 5768 *solar Years*.

† If, from what has been said, the *Learner* understands the various Motions of the *Earth*, he will easily conceive the Motions of the rest of the *Planets*. For, they all move in *Orbits*, like our *Earth*, round the *Sun*, which makes, in the same Manner, their *Year*.—They also revolve upon their



## Of the M o o n.

THE *Moon* is a *Secondary Planet*, differing from the rest, because she respects the *Earth* for the Center of her Motion; and not only her Globe, but her Orbit is carried (as it were) round the *Sun* together with our *Earth*; for which Reason she is called the *Earth's Satellite*, or *Attendant*.—She makes one Revolution round the *Earth*, with Respect to the *fixed Stars*, in 27 Days, 7 Hours, and 43 Minutes: This is called the *Periodical Month*. But the *Earth* having gone on, in that Time, one twelfth Part of her Orbit, and carried the *Moon* with her, she will not arrive to the same Position, with Regard to the *Sun*, as she was when she began her Course, till about 2 $\frac{1}{2}$  Days more. Hence, from one *new Moon* to another is about 29 $\frac{1}{2}$  Days, and this is called the *Synodical Month*; because, at every *new Moon* the *Sun*, *Moon*, and *Earth* are assembled in Conjunction, and lie in a right Line, the *Moon* being between them.

In every Revolution of the *Moon* round the *Earth*, she turns once upon her own *Axis*, and that is the Reason why the same Face is always presented to our View.

The *Moon* is considerably smaller than any of the Planets, but by Reason of her Nearness, she appears the biggest; her Distance being only 240.000 Miles from us. Her Diameter is found to be about 2175 Miles;—her Circumference 6829; which makes her Globe near 50 Times less than ours.

That the *Moon* has *Day* and *Night*, is evident from the Light and Shadow of the *Sun* seen upon it, moving round it from *West* to *East* in one Month.—That she has *Summer* and *Winter* is clear from her presenting sometimes more of her *northern* Parts, and at other Times more of the *southern*; by which also, we learn that her *Axis* inclines (like our *Earth's*) to the Plane of her Orbit, but not so much; hers being only 6 $\frac{1}{2}$  Degrees from the Perpendicular, but ours 23 $\frac{1}{2}$  Degrees.—That she has *Mountains*, *Seas*, and *Valleys*, is manifest from the Inequalities and Unevennesses in her Surface, which are plainly to be seen with the *Telescope*.—She is also supposed to have an *Atmosphere*.—And our *Earth* doth the Office of a *Moon* to the *Lunarians* (if any there) as their Planet does to us.

The brighter Parts of the *Moon* are supposed to be the various *Region of Land*, shining by the *reflected* Light of the *Sun*, the darker Parts are *Oceans*, *Seas*, and *Lakes*, which, as they *absorb* the Light, must appear more obscure; the bright *Spots* and *Streaks* of Light, are judged to be *Islands*, *Hills*, and long *Ridges of Mountains*, strongly illuminated by the *Sun*.

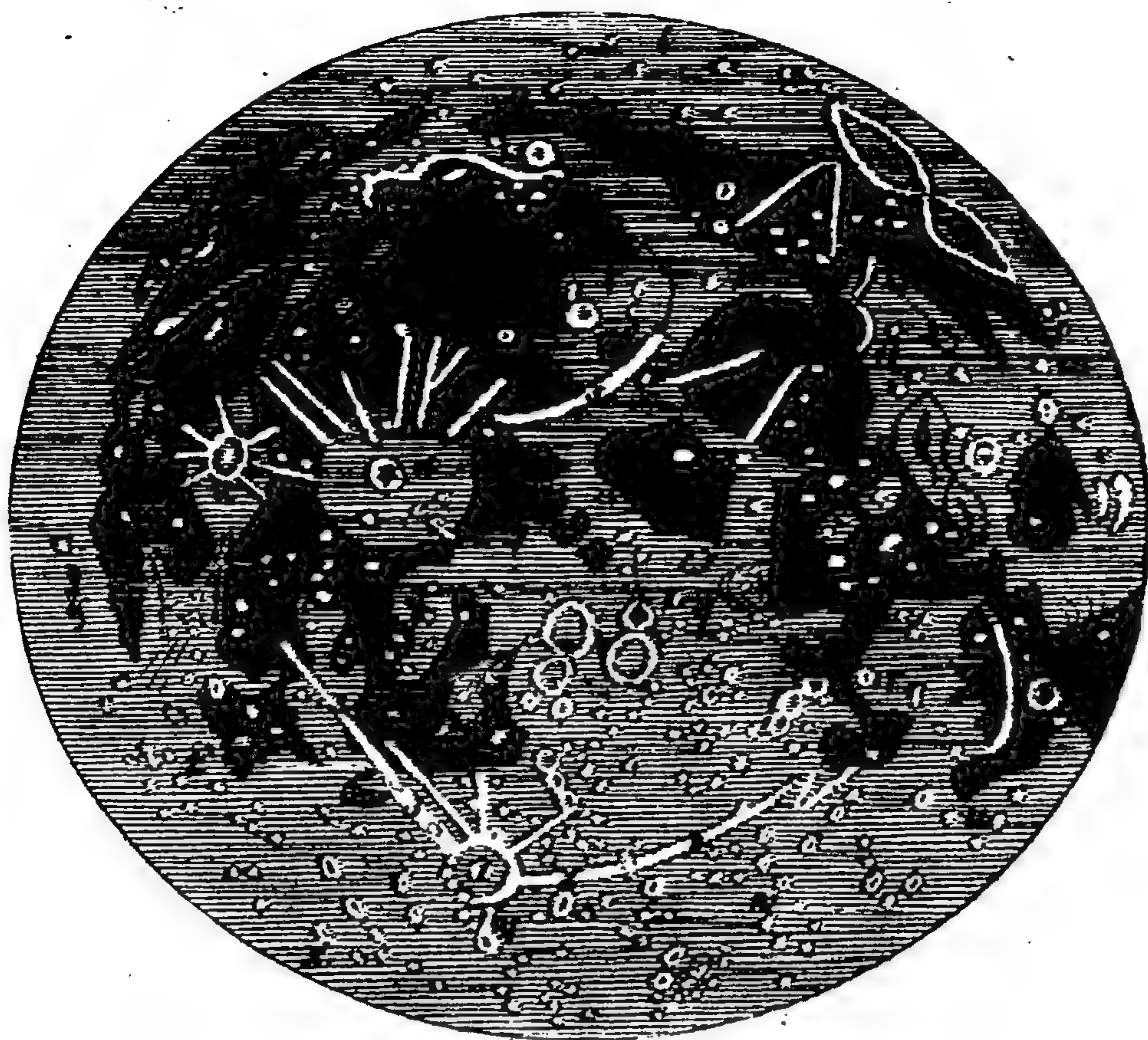
*Axes*, which produces the Returns of *Day* and *Night*.—From the *Inclination* of their *Axes* to the Plane of their Orbits, arises the Division of their Globes into *Torrid*, *Temperate*, and *Frigid Zones*.—By keeping their *Poles* always directed to the same Points of the Heavens, they must necessarily have the variegated Seasons of *Summer* and *Winter*.—And from their *Atmospheres* arise *Twilight*, *Winds*, *Mists*, &c. as upon our *Earth*; only, in some Planets, these *Phænomena* may happen in a greater or less Degree than upon the *Earth* itself.

\* The *Moon* appears to move every Day towards the *West*: This is caused by the *Earth's* daily Rotation upon her *Axis* the contrary Way. But her real Motion, like the rest of the Planets, is towards the *East*. For if you observe her any Night near a *fix'd Star*, you will find her the Night following considerably remov'd towards the *East*; and the next Night twice as far; and so on: Till she (compleating her Round) returns to the Star again.

The



The *Situation* of the several *Countries, Seas, and Mountains*, on that Hemisphere (or Face) which is always presented to our View, is as here delineated.



### The *Oceans, Seas, and Lakes* are,

- |  |  |  |   |
|--|--|--|---|
| <i>a</i> Mare Hyperboreum<br><i>b</i> Paludes Hyperboreæ<br><i>c</i> Sinus Hyperboreus | <i>d</i> Mare Eoum<br><i>e</i> Mare Mediterraneum<br><i>f</i> Pontus Euxinus | <i>g</i> Palus Meotis<br><i>h</i> Mare Caspium | <i>i</i> Mare Adriaticum<br><i>k</i> Propontis. |
|--|--|--|---|

### The *Countries and Islands* are,

- |   |  |   |   |
|---|--|---|---|
| <i>l</i> Regio Hyperborea<br><i>m</i> Sarmatia<br><i>n</i> Taurica Chersonesus<br><i>o</i> Italia | <i>p</i> Mæsia<br><i>q</i> Asia<br><i>r</i> Cholchis<br><i>s</i> Sicilia | <i>t</i> Peloponnesus<br><i>u</i> Scythia<br><i>w</i> Persia<br><i>x</i> Arabia | <i>y</i> Palestina<br><i>z</i> Ægyptus<br><i>Ë</i> Lybia<br><i>a</i> Infula Circunna. |
|---|--|---|---|

### The *Mountains and Hills* are,

- 1 Mt. Sinai—2 Mt. Taurus—3 Mt. Sepher—4 Mt. Ætna—5 Mt. Apenninus—6 Mt. Olympus\*.

The other Side of the *Moon* we are never permitted to see, nor the *Inhabitants* (if any) to see Us, without taking a Journey to this Side next us, and some of them must travel more than 1500 Miles to obtain a Sight of our *Earth* at all.

Another Thing, no less remarkable than wonderful and curious, is, that those who inhabit the Middle of the Surface next us (as about *Mount Olympus* and *Mare Adriaticum*) will see our *Earth* constantly *over their Heads*, and *increasing* and *decreasing* in Light like a *Moon*; whilst those who live near the *Borders* will see the same Appearances continually in the opposite Parts of their *Horizon*.

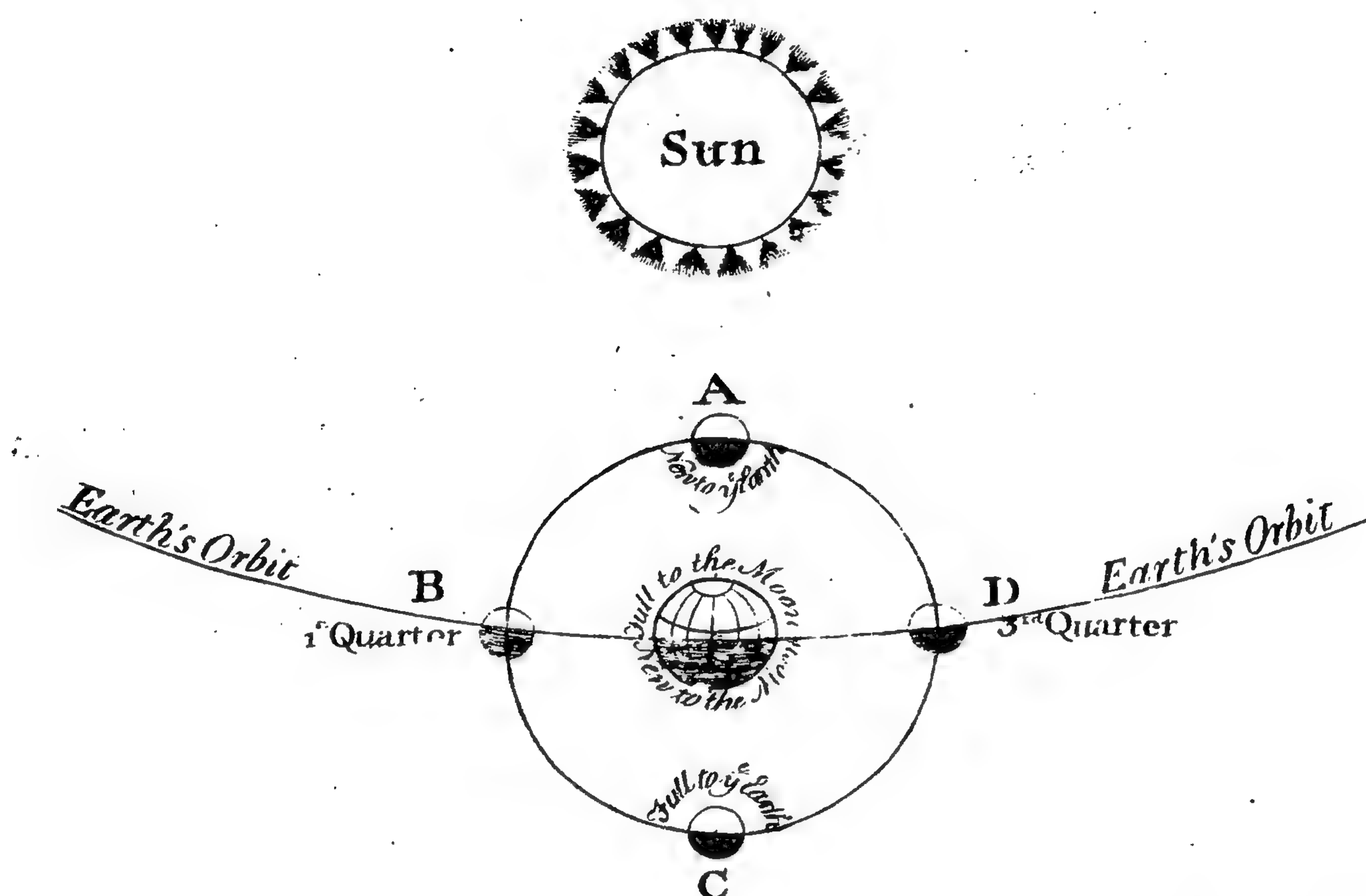
To the *Inhabitants* of the *Moon* in general, the *Magnitude, Light, and Heat* of the *Sun* are much the same as with us here, owing to her small Distance from us. But the Length of the *Day* in that Planet is equal to near 30 of

\* Some of these Mountains are thought to be higher than any on our Earth. Their Heights are easily obtain'd by *Trigonometry* See my Treatise on that Subject.



ours; that being the Time she takes to turn once round her *Axis*; so that her *Days* and *Months* are of the same Length; and the *Year*, to the *Inhabitants* there, is exactly equal to ours, because she turns each *Pole* towards and from the *Sun*, in the same manner as the *Earth* does in that Period of Time. But the Variety of Seasons, with regard to Heat in *Summer* and Cold in *Winter* is much less than upon this Globe, arising from a much smaller Inclination of her *Axis*, which is about  $6\frac{1}{2}$  Degrees: Consequently the *Torrid Zone* must be only 13 Degrees—the *Frigid Zones* the same—and the *Temperate Zones* 77 Degrees broad.

The *Lunarians* will observe our *Earth* to shine like a *Moon* to them, as theirs does to us. For, the *Earth* and *Moon* are mutually *Moons* to one another. Only, when they are a *new Moon* to us, we are a *full Moon* to them. And when they appear to *increase* in Light, we shall appear to *decrease* in the same Proportion, &c. All this is evident from a bare Inspection of the following Scheme.



From a Sight of this Figure it is manifest, that, that Half of the *Earth* and *Moon* next the *Sun* is always illuminated, and the other Half always dark; Consequently, when the *Moon* is at A, she is a *new Moon*, and invisible to us; but we are a *full Moon*, shining bright to them.—At B, she turns Half her illuminated Side towards us, where she is in the *first Quarter*; and we appear to the *Inhabitants* there in the *last Quarter*.—At C, she becomes a *full Moon*, shining bright upon us; whilst we are a *new Moon*, and invisible to them.—At D, she presents Half the illuminated Face again: Now she is in the *third Quarter*, and we in the *first*. When she returns to A her Revolution is complete, and the Appearances begin as before.—As the *Moon* passes from A round B to C, she gradually *increases* in Light;—is East of the *Sun*;—and rises and sets after him.—But in going from C by D to A, she *decreases* in the same Manner;—is West of the *Sun*;—and rises and sets before him.

There is one Thing further to be observed, which is, that the *Light* afforded by the *Earth* to the *Moon* is about 15 Times greater (the *Earth's* Surface being so many Times bigger) than that afforded by the *Moon* to the *Earth*: Which strong Reflection from the *Earth* occasions that *dusky Light* seen on the dark Part of the *Moon* for some Days near the *Change*.



## Of the Planet MARS.

*MARS* moves in an Orbit round the Sun, between the *Earth* and *Jupiter*, making one Revolution in the Space of 1 Year, 321 Days, 23 Hours, and 27 Minutes; at the Distance of 123 Millions of Miles. This Planet is of a Red Colour, (suppos'd to be owing to the Thickness of his Atmosphere, or Nature of the Soil to reflect that Redness) and has a Rotation upon his Axis, as appears from the Spots upon his Body, in 24 Hours and 40 Minutes. He is about 4440 Miles in Diameter, which makes him about six Times less in Bulk than our Earth.

*Mars*, when in *Opposition* to the Sun, is five Times nearer us than when in *Conjunction*; for this Reason he appears much larger and brighter at one Time than another. In the *Quadrature* he appears almost bisected like the Moon, but never horn'd, which is a Proof that his Orbit circumscribes ours, and lies wholly beyond it.

As this Planet is almost Half as far again from the Sun as our Earth is, his *Inhabitants* will see the Sun's Diameter but little more than Half as big; consequently, his Light and Heat is not Half so great as it is here. Their Year is almost twice as long as ours, and their natural Day is greater by about 40 Minutes.

The Axis of this Planet (as appears from the Revolution of the Spots upon his Surface) is nearly at Right Angles to the Plane of the Orbit; consequently, the Days and Nights are almost equal every where over the whole Globe. But Places in different Latitudes will partake of different Degrees of Heat and Cold, on account of the different Inclination of the Sun's Rays to the Horizon, as in the Case of our Earth, when the Sun is in the Equinoxes, in March and September.

Though Astronomers have not been able to discover any Moon belonging to this Planet, yet it is very probable he has one \*, else the *Inhabitants* will be depriv'd of that most useful Division of Time into Months, which we have measur'd out to us 12 Times in a Year, by that Number of Revolutions of our Moon round the Earth.

The Spectators of the Heavens in *Mars* will rarely, if ever, see *Mercury*, unless it is when that Planet, passing directly between them and the Sun, appears as a black Spot upon his Face, as he does sometimes to us. *Venus*, there, will appear about as far from the Sun as *Mercury* does with us; and the *Earth* will appear, as far as *Venus* appears to us to be from the Sun; and will become their Morning and Evening Star, by Turns, just as *Venus* does here. And when the *Earth*, seen from *Mars*, is in *Conjunction* with and near the Sun, she will appear (thro' a Glass) horn'd, as *Venus* does to us in that Position; and its Satellite, the Moon will be of the same Figure, if it can be seen there, and at its greatest Distance not above  $\frac{1}{4}$  of a Degree (or a Hand's Breadth) from the Earth.

\* As the Rotation of a Planet upon its Axis makes its Day, and the Revolution round the Orbit its Year; so the Revolution of a Moon about a Planet makes its Month: Consequently, if a Planet has no Moon surrounding it, it can have no Month, but only Days and Years.



## Of the Planet JUPITER.

NEXT beyond *Mars* we find the refulgent Planet *Jupiter*; moving round the Sun in 11 Years, 314 Days, and 12 Hours, at the Distance of 424 Millions of Miles from him. By the *Telescope*, he is found to have something like *Belts* surrounding his Body, near, and parallel to his *Equator*; in the lowest is a large *Spot*, by which his Rotation on his *Axis* was discover'd to be in 9 Hours and 56 Minutes. This Planet, as well as *Mars* and *Saturn* is much nearer the Earth when in Opposition to the Sun, than in any other Situation in his Orbit. He is upwards of 81.000 Miles in Diameter, which makes him about 1000 Times bigger than our Earth; and has 4 *Satellites* or *Moons* revolving round him to enlighten him by Night, as our Moon does us, in a constant direct Order, as follows:

1	} revolves in	1 D.	18 H.	} at the Distance of	5	} Semidiameters of <i>Jupiter's</i> Body.
2		3	13		9	
3		7	3		15	
4		16	18		26	

By these Distances, the *Satellites* may be easily distinguished from each other; and, by observing them with a *Telescope*, they may sometimes be seen to cast their *Shadows* upon his *Disk*, when they are found between him and the Sun; and at other Times to be *eclips'd*, by falling into his Shadow as they pass behind him.

By observing these *Eclipses* of *Jupiter's* *Satellites*, it is found that *Light* is not instantly convey'd to us, but takes up 7 or 8 Minutes to travel from the Sun hither, which is about 81 Millions of Miles \*.—And this vast Space Light passes through in so small a Time, that the Velocity of its Motion cannot be easily conceiv'd by us.

By the *Eclipses*, or *Immersions* and *Emersions* of these *Satellites*, or *Moons*, into and out of his Shadow, the Longitude of Places on our Globe may be found †.

\* When the *Earth* is between the Sun and *Jupiter* these *Eclipses* happen 7 or 8 Minutes too soon; and when the *Earth* is in the opposite Part of her Orbit, beyond the Sun, they happen as much too late than they should by the best Calculations: The Reason is, because the Light has further to go in the latter Case than the former, by the *Diameter* of the Earth's Orbit.

† Suppose I find, by Mr. *White's Ephemeris*, that the first *Satellite* of *Jupiter* will be immers'd into *Jupiter's* Shadow at 8 o'Clock at Night, at *London*, on some certain Day; but, being at Sea, I observe, with a *Telescope*, the *Immersion* to begin at 10 o'Clock the same Evening; the Difference, which is 2 Hours, turn'd in *Degrees*, allowing 15° for each Hour, shews that I am 30° to the East, because the Time is more than at *London*. Had the Time been 2 Hours less, I should have been 30° to the West. By this Method, the *Mariners* are enabled to correct their *Reckoning* by these *Moons* of *Jupiter*, which were never heard of or seen till discover'd, with the *Telescope*, by *Galileo*, on the 7th of *January*, 1610.

*Jupiter*



*Jupiter* is a little more than 5 Times further from the Sun than the Earth is, consequently his Diameter to that Planet is not a *fifth* Part of what it appears to us; and, therefore, his *Light* and *Heat* must be 25 Times less than ours.

Their *Year* is almost 12 of ours; but their *Days* and *Nights* are but short, being about 5 Hours each, tho' their year is so long and tedious. As the *Axis* of this Planet inclines but little (if any) to the Plane of his Orbit, the *Days* and *Nights* must be nearly equal, and the *Inhabitants*, over the whole Globe, throughout the Year, will enjoy, as they do in *Mars*, a perpetual *Equinox*.

The *Satellites*, or *Moons*, to the *Inhabitants* there, will appear as large, perhaps, as our Moon does to us here; and they will have four Kinds of *Months*, whose Lengths are determined by the Revolutions of their *Moons*. In one of *Jupiter's* Years, which is nearly 12 of ours, there will be about 2407 of the *least* Months:—1203 of the *second* Kind:—601 of the *third*:—and 254 of the *fourth* or greatest. A Year in *Jupiter* contains a great Number of their Days, not less than 108.200; but of the four Sorts of Months, the least contains only  $4\frac{1}{2}$  Days;—the *second* about  $8\frac{1}{2}$ ;—the *third*  $17\frac{1}{2}$ ;—and the *greatest* about 41 Days.

By the frequent *Eclipses* of these four *Moons* \*, the Navigators in *Jupiter* (if there are any) will be enabled to ascertain their *Longitude* better than we can here upon our Globe by the Assistance of our (one) *Moon*.

The *Astronomers* in *Jupiter* will never see *Mercury*, *Venus*, the *Earth*, nor perhaps *Mars*, (unless in their Horizon sometimes, at the Beginning and End of their *Twilight*) since from that Distance, they must appear to accompany the Sun, and rise and set almost at the same Time with him. Nor will they, without better Glasses than ours, be able to know there are such Worlds in Existence. But they will see *Saturn* and his *five* *Moons*, and perhaps be able to discover the *Seasons*, &c. in that Planet, something better than we can. *Saturn* will also appear to them sometimes *bigger* and sometimes *less*, as *Mars* does to us, as he is nearer or further off in his Orbit from them, as is clear from a View of the *System* itself.

\* The *Immersion*s of *Jupiter's* *Satellites* into his Shadow can only be seen when he is *West* of the Sun, and their *Emersions* when he is *East* of him. And when he is in exact *Opposition* to, or *Conjunction* with the Sun it will be in vain to look for either, because his Shadow, lying perfectly behind his Body, is impossible to be seen at the Earth.—The same Appearances happen with Respect to the *Satellites* of *Saturn*.



## Of the Planet SATURN.

**S**ATURN is the highest Planet, and most remote in our System, being distant from the Sun 777 Millions of Miles. He makes his Periodical Revolution in 29 Years, 174 Days, and 6 Hours. His Diameter is about 67.860 Miles, therefore he is 600 Times bigger than the *Earth*, and *Half* as big as *Jupiter*. He is observ'd to have always a round full Face, but is of a dull Lead-colour. It is uncertain whether this Planet revolves upon his *Axis* or not, because of his vast Distance from us. By viewing him through the *Telescope*, he is observed to have 5 *Satellites* moving round him, as he does round the Sun; and, according to the latest Discoveries, their Revolutions and Distances from him are as here set down :

1	} revolves in	1 D. 21 H.	} at the Distance of	4	} Semidiameters of Saturn's Body.
2		2 17		6	
3		4 12		12	
4		15 22		20	
5		79 7		59	

Those *Moons* all move round the *Equator* of *Saturn*, and cut his Orbit at Angles of about 30 or 31 Degrees.

Besides these 5 *Moons*, this Planet is found to have a surprising *Ring* encompassing him on every Side, but doth no where touch his Body. The Breadth of the *Ring* is about 21.000 Miles, and the Distance of it from *Saturn*, on every Part, much the same; so that, in some Situations, the Heavens may be distinctly seen between the *Ring* and his Body. It appears to be suspended over the *Equator* of that Planet; is judg'd to be about 7 or 800 Miles thick. And its use is suppos'd to give *Light* and *Heat* to the People there\*.

The *Ring* puts on many different Appearances to us at the Earth; for when *Saturn* is in 20° of *Sagittarius*, the *northern* Parts of the Planet being turn'd towards the Sun, making it *Summer* there, the *Ring* appears quite open.—When he is at 20° of *Pisces*, the *Ring* is quite *shut*, appearing only as a Line upon the *Equator*; then their Days and Nights are equal.—When he arrives to 20° of *Gemini*, the *southern* Parts are turn'd towards the Sun, and the *Ring* appears open again. Now it is *Summer* to the *southern* Inhabitants of that Planet.—When he is advanc'd to 20° of *Libra*, the *Ring* appears *shut* again, and the Sun being over their *Equator*, makes their Days and Nights equal, as in the opposite Part of his Orbit.

\* This surprising *Phænomenon* of *Saturn's Ring* is a modern Discovery; neither were the *Satellites* of *Jupiter* or *Saturn* known to the Ancients. The *Moons* of *Jupiter* were first discover'd, as observ'd before, by the famous *Italian* Philosopher *Galilæus*, with a *Telescope*, which he first invented in 1610. But Mr. *Hugens* first discover'd the biggest of *Saturn's Satellites*, which is the fourth, and the *Ring*, in 1665. The other four *Satellites* were discover'd by Mr. *Cassini*, the French King's Astronomer, the 3d and 5th in 1671, 1672, and 1673; but the 1st and 2d were not seen till the Year 1684, with extraordinary Glasses of 100 and 200 Feet in Length.—All *Jupiter's Moons*,—one of *Saturn's*, the 4th,—and *Saturn's Ring*, may be seen with a *Refracting Telescope* of 8 or 10 Feet, or with a *Reflecting* one of 18 Inches or 2 Feet.



To the *Inhabitants* of this Planet, the Sun appears *ten* Times less than to those on our Earth, as being *ten* Times further from him than we are; consequently his *Light* and *Heat* will be almost 100 Times less\*.—Cold and dreary Situation this, when compar'd to ours! But their *Natures*, no doubt, are suited to it; and our *Light* and *Heat* would be as intollerable to Them, as their *Cold* and *Duskiness* would be to Us.

*Saturn's Year* is almost 30 of ours; but the Length of the *Days* are wholly unknown to us: For we have not been able, on account of his vast Distance from us, to discover his Rotation on his *Axis*. There is, however, a vast *Inequality* in the Length of the *Days* in several Parts of this Planet, and as great Diversity of *Summer* and *Winter* and other *Seasons*, owing to the Inclination of the *Equator* to the Plane of *Saturn's Orbit*, which is about 30 or 31 Degrees.—Hence to the *Inhabitants* in the *Latitude* of 60 Degrees, their longest Day will have no Night, and, on the contrary, the longest Night will have no Day, just as with us under the *Artic Circle*.

The *Saturnians* (without better *Optics* than ours) see none of the Planets but *Jupiter*, and he appears to accompany the Sun, being never found, either before or after him, more than 34 or 35 Degrees. He therefore becomes their *Morning* and *Evening Star* by Turns, as *Venus* does to us. But they will see their own *five Moons*, perhaps, larger than ours, which will measure out to them five Kinds of *Months* of different Lengths. These *Moons* will *increase* and *decrease*, come to the *new* and *full*, and frequently *eclipse* each other and the Sun (as ours does here) as they revolve in their several Orbits round him.

The amazing *Ring* suspended in their Sky, will cast a Shadow (as the Sun moves Northward or Southward of their *Equator*) over vast Regions of *Saturn's Body*, which, removing from one Part to another, will cause great Changes in the *Light* and *Darkness* on that Planet. And it is very probable the *Inhabitants* may be ignorant of the Reason of these wonderful Varieties. For though we, here at the Earth, stand convenient to see it, and know it is owing to a mighty *Ring* surrounding his Body, yet it is not easy for them there to discover it. They must naturally imagine it to be in the Heavens, and have no Way of determining the Distance but from Observations made in different Latitudes. For tho' at their *Equator* it appears over their Heads, yet as they recede either Northwards or Southwards the *Ring* will appear lower, till at the Latitude of 60, perhaps, it will not be visible. So that from thence to their *Poles*, the *Inhabitants* (if any) will be totally ignorant of that wonderful Phenomenon. Nor can they see it without taking a Journey on purpose.

\* The *Diameters* of the heavenly Bodies appear to *increase* and *decrease*, as we approach or recede from them, directly as the Distance themselves; i. e. at *twice* the Distance they appear *Half* as large; at *thrice* the Distance *three* Times less.—But the Proportions of *Light* and *Heat* increase and decrease inversely, as the Squares of those Distances; i. e. at *twice* the Distance it is *four* Times less light and hot; at *three* Times the Distance, *nine* Times less.—And the *Bulk*, or solid Contents of those Bodies are to each other directly as the Cubes of their Diameters; i. e. if the Diameter of one Planet be *double* the Diameter of another, then the Bulk of the larger is *eight* Times greater than that of the smaller; if the Diameter be *three* Times greater, then it is *twenty-seven* Times bigger; and so of any other.

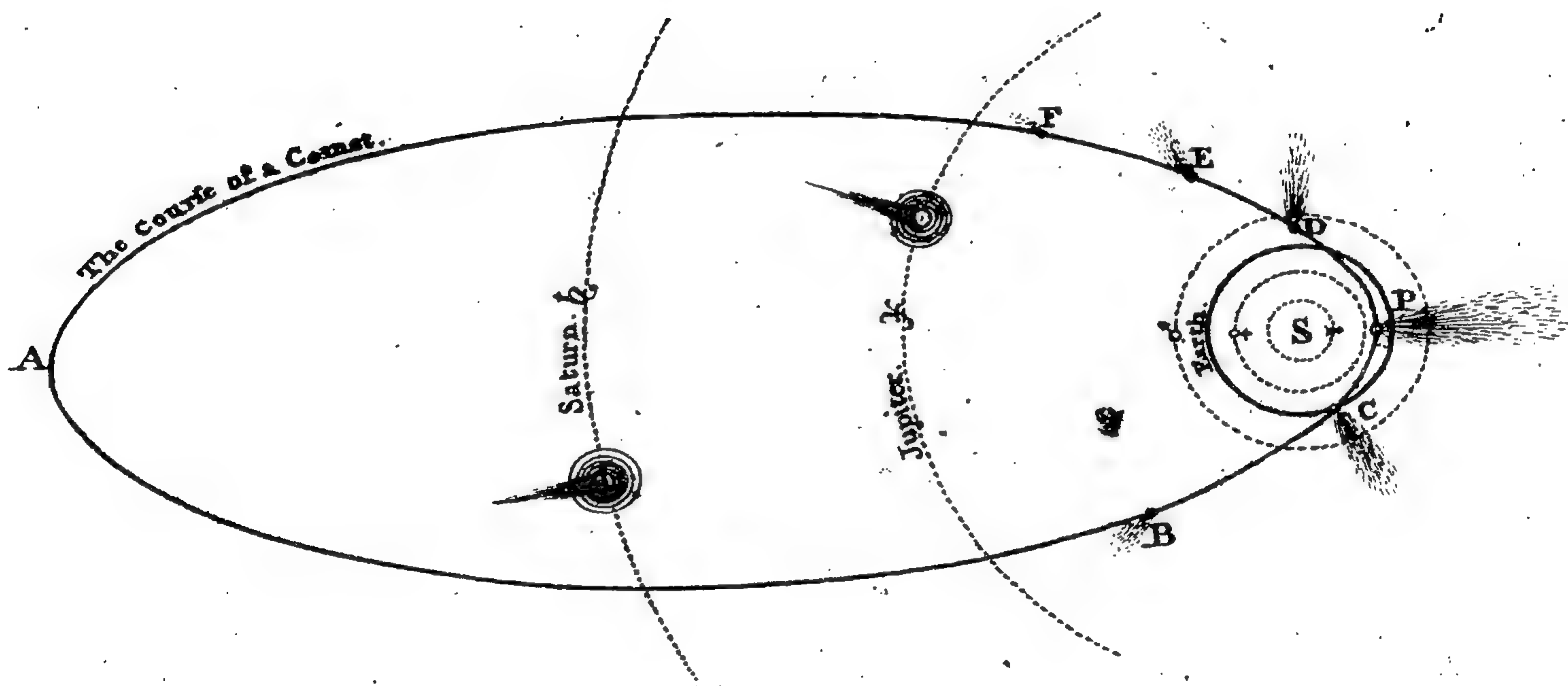


## Of the COMETS.

**B**ESIDES the *Planets* already treated of, there are other large Bodies belonging to our *System*, which are (as it were) a kind of temporary *Planets*; for they sometimes make their Appearance in our Regions for a while, and then disappear for a certain Space of Time, after which they return again. — These wandering Bodies are call'd *Comets* or *Blazing Stars*.

The *Antients* thought them to be *Meteors* or *Exhalations*, set on fire in the middle Regions of the *Air*: But the modern *Astronomers* have found that they are large globular Bodies, moving in various Directions across the *System*; and that their Orbits are not *circular*, like those of the *Planets*, but very *elliptical*, or oval; and therefore, they are sometimes at a moderate Distance from us; at other Times, they ascend to vast Heights above *Saturn*, and so become invisible, till they return into our Part of the Heavens again.

The Manner in which a *Comet* revolves in its Orbit round the *Sun*, and through the *System* is here delineated.



In this Scheme, S represents the *Sun*; A, B, C, P, D, E, F, the *elliptic* Orbit of a *Comet*; the black Circle C, P, D, the Orbit of the *Earth*; and the dotted Circles the Orbits of the rest of the *Planets*. Now the *Comets* are found to revolve round the Sun in the same Manner as the *Planets*, differing from them only in the Form of their Orbits; for in the *Planets* their Orbs are nearly *circular*, but those of the *Comets* are long *Ellipses*. And the greater the *Ellipses*, are the further will they stray from the Sun at one Time, and the nearer approach him at another: consequently, they must suffer great and different Degrees of Heat and Cold. When a *Comet* is at A, it is at its greatest Distance from the Sun, far beyond the Orbits of the most distant *Planets*; and, as they are not much larger than the *Moon*, (some few, perhaps, as large as the *Earth*) they remain hid from our Sight. But as they descend within the *System*, they become *visible*, appearing, at first, like Stars of the smallest Magnitude; and as they approach the Sun they continually grow larger, till, at last, they exceed Stars of the largest Size.

When



When the *Comet* arrives at or about B, near the Orbit of *Mars*, it will be seen, perhaps, beginning to emit a small lucid *fiery Tail*, from the Heat it then receives from the *Sun*. As it approaches nearer, the Heat increasing, the *Tail* grows longer. At the *Perihelion*, at P, and a little beyond it, the *Tail* is longest of all. From thence, as the *Comet* continually ascends, and the Heat diminishes, the *fiery Tail* begins to contract its Dimensions, and grow less and less, till it becomes invisible about F; after which it is seen no more, without a *Telescope*, till it returns again.

The *Comets* themselves are suppos'd to be *hard, dense, durable* Substances, like the rest of the Planets; but their *Tails* seem to be owing to some *peculiar, rare, and luminous* Matter, in their Atmosphere, which is easily excited by the *Sun's Heat*, and thrown off in fiery Vapours, always into the Regions opposite the *Sun* \*. The *Magnitude* and *Length* of the *Tail*, depends chiefly on the Heat it receives from the *Sun*; whence, the nearer a *Comet* approaches the *Sun*, the longer is its *Tail*.

The *Tails* of the *Comets* are observ'd to put on various Appearances. For sometimes they appear of a vast *Length*, growing *wider* and *thinner*, the farther they proceed from the Body of the *Comet*. At other Times they appear *shorter*, and with a *narrower Termination*, like a *Sword*. And sometimes, the *Tail* seems to surround the *Comet*, with fine lucid Beams, like *Hair*. All which Variety of Aspects arise from the Position of the *Tail* with respect to us at the Earth.

Some of the *Tails*, near their Extremities, are so very fine and transparent that the fix'd Stars may be distinctly seen through them: And their Lengths become sometimes so amazing, as to take up more than 40 Degrees in the Heavens; which, considering their Distances at that Time, cannot measure less than 70 or 80 Millions of Miles.

The *Comets* moving in very long *elliptical* Orbits, and becoming visible to us only through the small Part of their Course near the *Sun*, and remaining lost, as it were, and unknown to us through their immense Journeys beyond *Saturn*, their *Periods* cannot be so easily determin'd as those of the *Planets*. And when a *Comet* does return, we are not certain it is the same, but by comparing its Direction through the Heavens with some one that has appear'd there before.

By this Method, we know that the Period of the *Comet* which appear'd in 1680 is 575 Years, because one of the same Kind was seen in the Year 1106; and once before about the Year 532; and also 44 Years before *Christ*. This *Comet*, at the time it appear'd last, came so near the *Sun*, as to be within one sixth Part of the *Sun's Diameter* from the *Sun's Body*; consequently, it must receive a Degree of Heat 28.000 Times hotter than our Earth in *Summer*; which is about 2000 Times hotter than *red-hot Iron*.—This is a Proof that the Bodies of the *Comets* are extremely *fix'd* and *durable*, else they must be totally dissipated and consum'd by such an intense Heat.

\* As to the Cause of the Ascent of the *Tail*, *Kepler* ascribes it to the Rarefaction of the *Comet's Atmosphere* by the Heat of the *Sun*, and the impulsive Force of the *Sun's Beams*, carrying along with the Matter of the *Comet's Tail*; which also accounts, at the same Time, for the Direction or Position of the *Tail*, which is always towards the Parts opposite to the *Sun*.



The Revolution of another *Comet*, which appear'd in 1682, is suppos'd to be 75½ Years, because such an one was seen in 1607, 1531, and 1456. Its Return was expected in 1758, but was not seen till the Beginning of 1759, at which Time it was visible in many Parts of *America*; and observ'd to be ascending back from the Center of the System. This *Comet*, at its nearest Approach to the Sun came within the Orbit of *Venus*, and receiv'd a Degree of Heat greater than that of *boiling Water*.

Another *Comet*, which was seen in 1661, and before in 1532, will probably return again in the year 1789, making its Tour round the Sun in 129 Years.

The Number of the *Comets* is imagin'd to be about 24 or 25; but these Periods are all that are certainly known to our Astronomers at present; and are what we must content ourselves with, till further Observations and Discoveries are made.

These amazing Bodies, in their Journies to and from the Sun, move in all manner of *Directions* across the Orbits of the Planets\*. For some revolve from *West* to *East*; others, on the contrary, from *East* to *West*: Some, again, move from *North* to *South*; and others, nearly *perpendicular* to the Plane of the Planets Orbits. And as they are sometimes burning with intense Heat in the Neighbourhood of the Sun, and at other Times scarcely receiving any friendly Influences from him; it cannot be suppos'd that they are Places of Habitation; and design'd for Animals and Vegetables, as the Planets are.

What then may be the *Uses* of these wonderful Bodies and their fiery Tails to the System, is, at present, only conjectural.—Some have suppos'd, that in each Revolution they accede nearer the Sun, till at last, falling upon his Surface, they supply him with fresh *Fuel*.—Others have thought, that their Tails are fine *volatile Spirits* excited by the Heat of the Sun, and dissipated through the System, to refresh the *Atmospheres* of the Planets, and supply them with those *vivifying Spirits* so necessary to sustain the Life of *Animals* and *Vegetables* there.—Some, again, have look'd on them, on Account of the excessive *Heat* they receive near the Sun, and the intense *Cold* they must suffer at their greatest Distance from him, to be proper *Receptions* for the Habitation of the *Damn'd*.—Whilst others have concluded them, with greater Probability, to be the *Executioners* of God's Vengeance on sinful *Worlds*; by scattering their *baneful Influences* on the Inhabitants, or dashing the *Planet* to Pieces, and reducing it to its *chaotic State* again.

The learned Mr. *Whiston* has made it very probable, that a *Comet* passing by our *Earth*, in its Descent towards the Sun, and involving us in its *Tail*, in the Days of *Noah*, was the Cause of the *Deluge*; and that another, sometime hence, in its Ascent from the Sun, after having been thoroughly ignited there, may bring about the *General Conflagration*.

\* As many of the *Comets* are observ'd to revolve in a *Direction* contrary to the Planets, and with a great and regular *Velocity*; we are assur'd there can be no *solid Orbs*, as the *Antients* suppos'd; nor *Vortices*, or *Whirlpools*, of subtle Matter in the Heavens to carry the Planets round the Sun, as the *Cartesians* imagin'd. For if there were such *Circulations* of ethereal or subtle Matter, the *Comets* would, when they enter'd into the *Regions* of the Planets, be necessarily driven from their Course by the rapid Motion of such a *mighty Torrent*, and be carried the same Way with the neighbouring Bodies. But, as ocular Demonstration assures us that no such Thing happens to the *Comets*, but that they preserve their Motions with the greatest Freedom, as in a perfect Void or *Vacuum*; we must acknowledge, that in the Heavens there is no Resistance, and consequently, no *Medium*, or *Fluid*, which can have any sensible *Density*; but that all the Spaces *between* and *beyond* the *Planetary System* are an immense *Vacuity*, admitting nothing but the Rays of *Light*, unless near the *Atmospheres* of the *Comets* and *Planets*; and, consequently, that all Solutions of the *Phænomena* of the *Heavens*, depending on the Supposition of such a *subtle Matter*, are *false*, and contrary to the evident State of our *System*.



# Of the FIX'D STARS.

**A**T a vast Distance beyond the Orbits of all the *Planets* and *Comets*, we behold, in a clear Night, the azure Concave studded over with *Stars* of different *Lustres* and *Magnitudes*. And because they retain the same Distances and Situation with respect to each other at all Times, they are justly call'd *fix'd Stars*, to distinguish them from the *Planets*, which are continually wandering from Place to Place. Their *Distance* from us must be immensely great, since there is no visible Alteration in their Positions, with respect to each other, when viewed from different Parts of the Earth's Orbit; consequently, the whole Orbit of the Earth, which is 162 Millions of Miles in *Diameter*, is but a Point in Comparison to it.

*Astronomers* have computed the Distance of the *greatest*, and consequently the *nearest fix'd Star*, to be about *Two Millions of Millions* of Miles\*; which is so very great, that a *Cannon-ball* would scarcely arrive thither in 700.000 Years, though it should roll on with the same *Velocity* it receiv'd at the Mouth of the Cannon. And it is very probable that they are situate as far from one another.

From the *fix'd Stars* being visible at such an immense Distance, we conclude that they do not shine with a *reflected* or *borrow'd Light*, like the *Planets* which are near us, but with their own *native Glory*, which they must have in themselves, like our Sun; and, therefore, are Bodies similar to him. And were we to be remov'd as near the *fix'd Stars* as we are to our Sun, they would appear as large, perhaps, as he does; and our Sun, beheld from thence, would appear a *twinkling Star* among the Rest.

The *Stars*, as they appear of different *Sizes*, are divided, for Distinction's sake, into Six different *Magnitudes* or *Classes*; of which the *largest* and *brightest* are call'd of the *first Magnitude*. Next these, are the *second Magnitude*; and the next Size, are Stars of the *third Magnitude*; and so on to the *sixth*, which are the smallest that can be seen by the naked Eye in the clearest Night; but it is seldom that we can see those that are smaller than the *fourth Magnitude*.

Several *Catalogues* have been made of the *fix'd Stars*: The *first* was by *Hipparchus*, the *Rhodian*, on seeing a New Star † in the Heavens, about 120 Years before Christ; his Catalogue contain'd 1022 Stars. After him, *Ptolomy* enlarg'd that Catalogue to 1026. *Ulug Beigh*, the Grandson of *Tamerlane* the Great, made a Catalogue of 1017 Stars. *Tycho Brahe* determin'd the Places

\* Mr. *Hugens* supposing the *fix'd Stars* of the same Magnitude with our Sun, found that *Syrius*, or the *Great Dog*, which is the *largest*, and therefore, very probably, the *nearest*, appear'd about 27.000 Times less than the Sun: His Distance must therefore be 27.000 Times as far; that is, upwards of 2 Millions of Millions of Miles.—Dr. *Bradley*, from a very subtle Calculation, makes the Distance still greater.

† The *Twinkling* of the *fixed Stars* is owing to the exceeding Smallness of their apparent *Diameters*, occasion'd by their immense Distance; so that every little Particle of *Dust* that floats in the Air, when it comes between the *Star* and the *Eye* will *eclipse* it; and as the Air is full of various Kinds of Particles, some of them are constantly passing between the *Eye* and the *Star*, and consequently cause the *Star* to *twinkle*.

‡ It is seldom we are favour'd with the Appearance of a *New Star*; but at present there is a wonderful one in the Neck of the *Whale*, which is observed to appear and disappear periodically, its *Period* being *Seven* Revolutions in *Six* Years.



of 777 *fix'd Stars*, and reduc'd them to a Catalogue. *Kepler's* Catalogue contain'd 1163. The Prince of *Hesse's* Catalogue was of 400 Stars. *Ricciolus* enlarg'd *Kepler's* Catalogue to 1468. *Bayerus* is said to have describ'd the Places of 1725, and mark'd each Star with a Letter of the *Greek Alphabet*: The biggest Star in each Constellation being denoted by the *first* Letter; the next Size by the *second*; and so on to the smallest. After him, *Hevelius*, of *Dantzick*, compos'd a new Catalogue of 1888. But the largest and best is that of Mr. *Flamsteed's*, which contains about 3000; of which Number it is seldom that a good Eye can see more than 100 together: And Mr. *Flamsteed* himself asserts, that the naked Eye can discover *no more than 384 Stars*, in the clearest Night, in both *Hemispheres*. But, with an ordinary *Telescope*, we can discover, in some Parts of the Heavens, 10 Times as many as were visible to the Eye before; so that we have Reason to believe, that only the *all-wise* and *powerful Being*, who fram'd them, is able to *tell the real Number of the Stars*, and call them by their Names.

The *ancient Astronomers*, the better to distinguish and describe the *fix'd Stars* from one another, have drawn them upon *Globes* and *Maps*, in 48 *Images* or *Parcels*, as of *Men*, *Lions*, *Bears*, *Triangles*, *Crowns*, &c. whence it comes to pass, that every *Star* has a Name from that Part of the Image it is situate in; as, the *Bull's Eye*, *Lion's Heart*, *Orion's Belt*, &c.—Some *modern Astronomers* have added 29 *Constellations* more, which were unknown to the *Antients*; and which are form'd from those *Stars* lying between the other *Constellations*; and are depicted on the *Globe* in a *fainter* Character.

The *Names* of the several *Constellations*, and the Number of *Stars* visible in each, you will find upon the *Cælestial Globe*, laid down exactly corresponding with those in the Heavens.

The *Constellations* on the *North Side* of the *Ecliptic* or *Zodiac*, are 34.

The *Little Bear*, *Great Bear*, *Boötes*, *Crown*, *Dragon*, *Cæphus*, *Hercules*, *Harp*, *Swan*, *Perseus*, *Andromeda*, *Cassiopeia*, *Auriga*, *Lynx*, *Little Lion*, *Greybounds*, *Charles's Heart*, *Lizard*, *Serpent-holder*, *Serpent*, *Dart*, *Camelopardus*, *Berenice's Hair*, *Mount Menalus*, *Eagle*, *Goose*, *Fox*, *Antinoüs*, *Dolphin*, *Little Horse*, *Pegasus*, *Great Triangle*, *Little Triangle*, and *Fly*.

The 12 *Signs*, or *Constellations*, of the *Ecliptic*, or *Zodiac*, through which the Planets all move in their yearly *Revolutions*, are,

♈ *Ram*, ♉ *Bull*, ♊ *Twins*, ♋ *Crab*, ♌ *Lion*, ♍ *Virgin*, ♎ *Scales*, ♏ *Scorpion*, ♐ *Archer*, ♑ *Goat*, ♒ *Water-bearer*, ♓ *Fishes*.

The *Constellations* on the *South Side* of the *Ecliptic* or *Zodiac*, are 31.

The *Whale*, *Orion*, *River Po*, *Hare*, *Great Dog*, *Little Dog*, *Ship*, *Crow*, *Hydra*, *Cup*, *Centaur*, *Wolf*, *Altar*, *South Crown*, *South Fish*, *Phænix*, *Crane*, *Unicorn*, *Indian*, *Peacock*, *Dove*, *Chamælion*, *Bird of Paradise*, *Indian Fly*, *Flying Fish*, *Sword Fish*, *South Triangle*, *Oak*, *Toucan*, *Hydrus*, and the *Cross*.

Besides



Besides these *Constellations*, there is a *whitish Tract* in the Heavens, call'd the *Milky Way*, passing round thro' *Auriga*, southward, by the *Twins*, the *Great Dog*, the *Ship*, and returns by the *Scorpion*, *Archer*, *Serpent-bearer*, *Eagle*, *Swan*, *Cassiopeia*, and *Perseus*, back to *Auriga* again. This *Path* is of unequal Breadth, and in some Parts, dividing itself, becomes *double*. It is suppos'd to be form'd by an infinite Number of small *Stars*, visible only through the *Telescope*, which, combining their Light in those Parts, cause that *shining Whiteness*. We have a fine View of it, in the *Evenings*, in the Months of *February* and *August*. There are several dusky or cloudy *Spots* in the Heavens, (particularly one in the *Crab*) which are suppos'd to be owing to the same Cause as the *Milky Way* \*.

Some have wonder'd at the great *Irregularity* which appears in the Disposition of the *fix'd Stars*; but that *Irregularity* is of the *greatest Use*: For, from thence it is the Heavens become divisible into *Signs* and *Constellations*, which a regular Situation would have render'd impossible. By this means we are enabled to ascertain, at all Times, the *Revolutions* and *Places* of the *Planets*, and to render their Motions serviceable to us here.

The *rising* and *setting* of the *fix'd Stars*, their apparent Motions every Night to the *West*, is owing to the *Earth's* Rotation upon its *Axis*, every Day, toward the *East*. And our seeing different *Stars*, at different Seasons of the Year, is owing to the *Earth's* Revolution in its Orbit round the Sun, as delineated at Page 8.

The whole Body of the *fix'd Stars* appears to have a slow progressive Motion † (parallel to the *Ecliptic*) towards the *East*, of about 50'' yearly, *i. e.* 1° in 70 Years; consequently, they do not complete *one Revolution* in less than 25.920 Years; after which Time they all return to the same Places again. This long *Period* was call'd the *Great Year*, and the *antients* imagin'd that when it was finish'd all Things would begin anew, and return in the same *Order* and *Manner* as before.

\* Some of the largest Stars have particular Names given them; as *Aldebaran*, a large Star in the Bull's Eye;—*Castor* and *Pollux*, two remarkable Stars in the *Twins*;—*Regulus* and *Deneb*, both of the first Magnitude, the former in the Lion's Heart, the other in his Tail;—*Syrius*, a glorious Star in the Jaws of the Great Dog;—with many others, which you will find inserted in their proper Place on the *celestial Globe*.—The *Ancients* plac'd these Figures in the Heavens, either to commemorate the Deeds of some great Men, or some remarkable Exploit or Action; or else took them from the Fables of their *Religion*, &c. And the *Moderns* retain them, to avoid the Confusion which would arise by making new ones, when they compare the modern Observations with the old Ones.—Those Stars which lie between the several Constellations, not cover'd by any Figure, are call'd *unform'd Stars*.—The Division of the Stars into Images and Figures is of great Antiquity, probably as old as *Astronomy* itself. For in the most antient Book of *Job* we read of the Constellations *Orion*, *Arcturus*, the *Pleiades*, and *Mazzaroth*; which last is suppos'd to express the 12 Signs of the *Zodiac*.

† This Motion of the *fix'd Stars* is not *real* (like that in the Planets) but *apparent* only; being caus'd by the spheroidical Figure of the Earth, turning its *Axis* continually, by little and little, (from its Parallelism) towards the *West*; which, consequently, must make all the Stars appear to advance forward just as much towards the *East*.



# Of the IMMENSITY of the UNIVERSE.

**T**HE *Ancients* look'd upon the azure *Firmament* of the fix'd Stars to be the Boundary of the Universe, and that they were plac'd (as it were) in a solid *Arch*, at an equal Distance from us. But the *Moderns*, since the Invention of *Telescopes*, have suppos'd, and with greater Probability, that every *fix'd Star* is a *Sun* furrounded with *Planets* and *Moons* like our own. Which several *Sys-*  
*tems* of the *fix'd Stars*, as they are at great and sufficient Distances from the *Sun* and *Us*, so are they conceiv'd to be at proper and regular Distances from one another. Hence it is that the *fix'd Stars*, which though perhaps nearly of the same Size, appear to us of *different Magnitudes*;—the nearest largest, those further off, less and less.

To suppose these glorious Bodies were all created only for our Use;—purely to scatter over our Globe a little dim Light in a Winter's Night, is forming very slender *Ideas* of the *Divine Wisdom*; since one *Luminary* deposited at a proper Distance, would have been more beneficial, on that Account, than all their twinkling Rays united together.—Far more *rational*, as well as more to the *Glory of God*, is the Supposition that every *fix'd Star* is a *Sun*, furrounded with a *System* of *Planets*, which, at *different Distances* and in *different Periods* of Time, perform their *diurnal* and *annual* Revolutions round him.

In what Part of the Universe our *System* is plac'd;—whether in the *Center*, or nearer the *Extremities*;—or whether there are not nobler Systems somewhere through the amazing Workmanship of God, are *Problems* beyond our Abilities at present to determine\*. For, by Reason of their vast Distances, our best *Telescopes* are found too weak to discover actual Globes revolving round their respective *Suns*, yet we can clearly enough discover that the *fix'd Stars* have in themselves the Nature of *Suns*; and that some Things, similar to Planets, sometimes appear and disappear in the Regions or Neighbourhood of those Bodies.

What an amazing Scene does this display to us!—What an inconceivable *Vastness* and *Magnificence* of *Power* and *Wisdom* does such a Frame unfold!—*Suns* beyond *Suns*, to our weak Sense indefinitely distant from each other, and *Myriads* of Mansions, like our own, peopling Infinity, all subject to the *Creators Will*!—An Universe of Worlds, all deck'd with *Mountains*, *Lakes*, and *Seas*; with *Rivers*, *Trees*, and *Animals*, various as the Globes they inhabit!—All the Produce of *indulgent Wisdom* to cheer Infinity with endless Beings, to whom his *Omnipotence* may give a *variegated eternal Life*.

\* The Rev. Mr. *Hervey*, in his *Meditations*, has given a most magnificent Description of the *Universe*. “ Could we (says that Author) wing our Way to the highest apparent Star, we should there see other Skies expanded, other *Suns* that distribute their inexhaustible Beams of Day, other Stars that gild the alternate Night, and other, perhaps, nobler Systems establish'd; establish'd in unknown Profusion through the boundless Dimensions of Space. Nor does the Dominions of the great *Sovereign* end there: Even at the End of this vast Tour, we should find ourselves advanc'd no further than the Frontiers of Creation, arriv'd only at the *Suburbs* of the great *Jehovah's Kingdom*.”



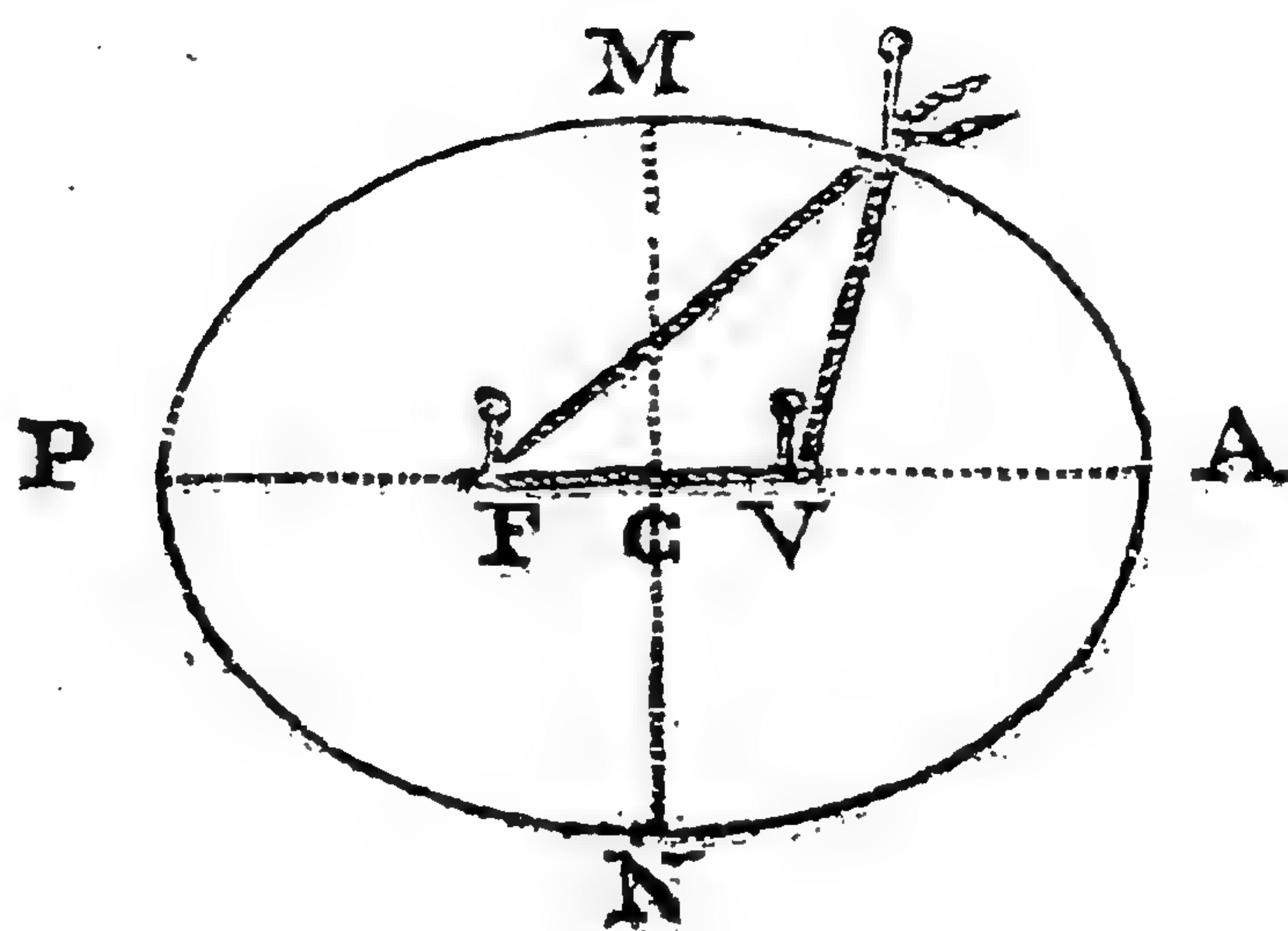
# Of the true Figure of the Planets Orbits:

WITH THE

Nature of their *Motions* in them ; and their *Situations* with respect to the *Ecliptic* ; also their *Aphelions*, *Perihelions*, *Inclinations*, and *Nodes*.

**T**HE *Planets* do not revolve round the *Sun* in Orbits exactly *circular*, but a little *elliptical* ; consequently, they are sometimes a little *nearer*, and sometimes a little *further* from him. For the better understanding their *Motion*, it will be necessary to shew how to delineate an *Ellipsis* ; which the Learner may take as follows.

Fix upright (upon any Plane) two Pins, as at F and V ; round these tie a Thread, *something longer* than their Distance from each other ; then apply, in the Doubling of the Thread, another Pin, or Pencil, so as to keep the Thread properly strain'd ; and in that Manner carrying the Pin round, with a steady Hand, the Point of it will describe a Curve we call an *Ellipsis*. — The nearer the Pins are together the more circular will the Figure be ; so that when they unite, or stand together, the Thread will describe a perfect Circle. — The two Points, F and V, where the Pins stand, are call'd the two *Focusses* of the *Ellipsis*. The Line PA, going through the the *Focusses*, from one End to the other, is called the *longer Diameter* ; and the Line MN, cutting the former in the Middle between the *Focusses*, is the *shorter Diameter*. The Point where these two Diameters intersect each other at C, is the *Center* of the *Ellipsis*.



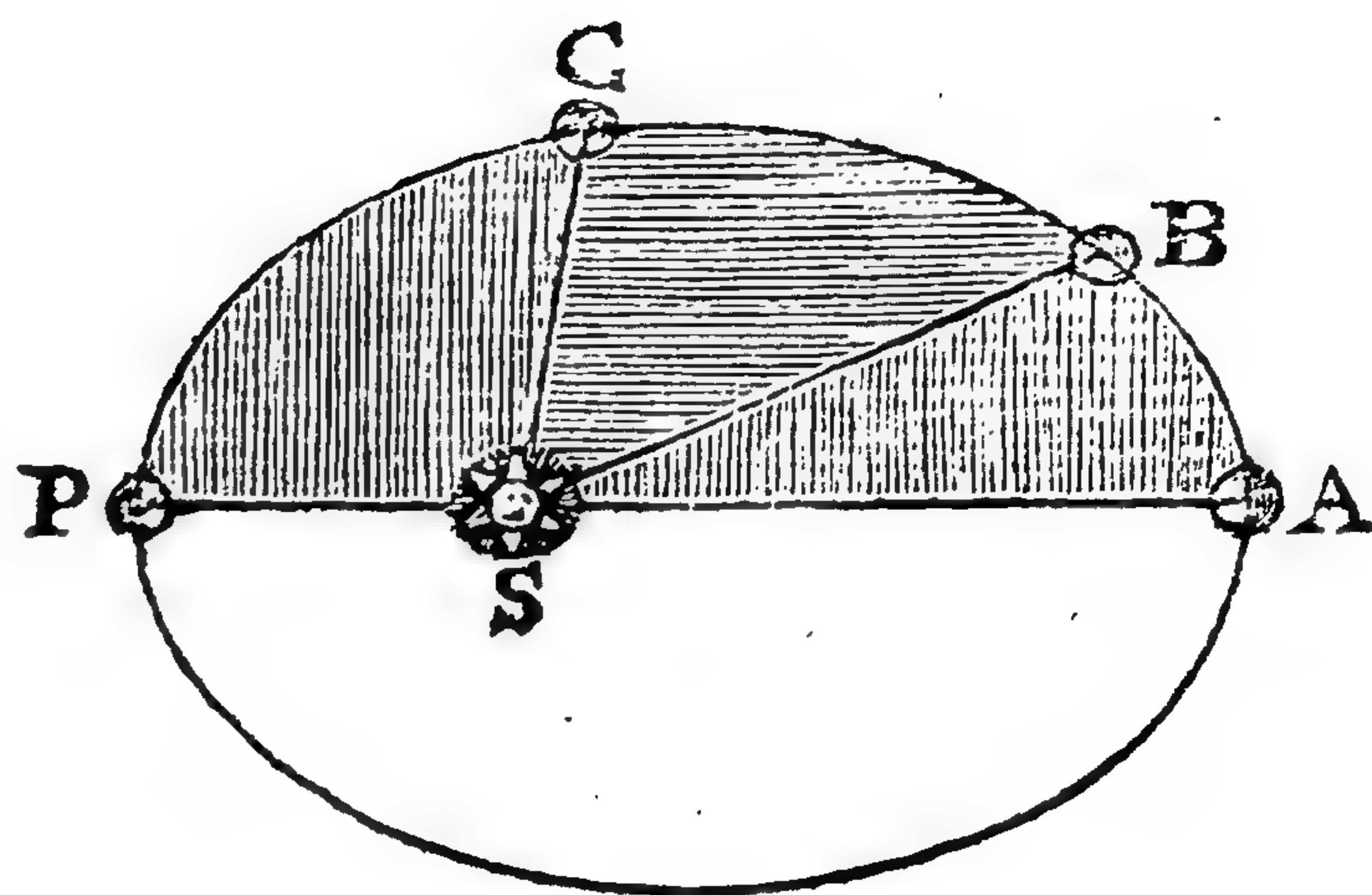
Now each of the *primary Planets* in their yearly Revolutions round the *Sun*, describe a Line of this kind \* : For the *Sun* is not plac'd in the Middle of their Orbs, at C, but in one of the *Focusses*. — Suppose the *Sun* to be plac'd at F ; then will the *Planet*, when at P. be *nearest* the *Sun*, and at A *furthest* from him. The Point P is call'd the *Perihelion* of a *Planet* ; and A the *Aphelion* : And the Points M and N are the *middle* or *mean Distances*, because the Distances FM and FN are a *mean* between FP the *least*, and FA the *greatest Distance*. The Distance FC, or CV, is call'd the *Eccentricity*, which is different in the different Orbits of the Planets, but in all of them it is so little, that in all small Schemes made to represent their Orbits, it is needless (and almost impossible) to express it. But, in the Orbits of the *Comets*, the *Eccentricity* is very considerable ; for their Orbs are very long *Ellipses*, and the *Focusses* at vast Distances from one another.

\* The Way we came to know that the Orbit of the *Earth* is *elliptical*, is, because the *Sun* appears of different Sizes at different times of the Year. In *June*, his Diameter is about  $31\frac{1}{2}$  Minutes ; but in *December*,  $32\frac{1}{2}$  Minutes. The *Earth* also is found to move slower in the former Case than in the latter. It must, therefore, necessarily follow, that we are further from the *Sun* in *Summer* than in *Winter*, and that our Orbit must be *elliptical*.



As the *Planets* are sometimes *nearer*, and sometimes *further off* the *Sun*, the Velocity of their Motions must be different in different Parts of their Orbits.—For, when the *Planet* is at A, in its *Aphelion*, (or most distant Part of its Orbit) the *Sun's* Action upon it will be less than in any other Part; consequently, its Motion *there* will be the *slowest*. But, as the *Planet* proceeds from A towards P, in the Figure below, its Motion (as it is continually coming nearer the *Sun*) will be continually *accelerating*, or *increasing*, till it arrives at P; where the *Sun* acting upon it with the greatest *Force*, the *Planet* will move with the greatest *Swiftness*. And as it revolves from P, its *Perihelion*, it will slacken, by little and little, its Pace, as it recedes further from the *Sun*, till it comes to A, where the Motion is *slowest* of all.—Now, since the Motion of the *Planets* is so *unequal*, the *Arches* thro' which they pass in certain given Times, must be so too.

Though the *Planets* move through *unequal* Spaces in *equal* Times, yet it has been discover'd, that the *triangular* Spaces within the Orbit, made by Rays drawn from the *Sun* to the *Planet* will be always *equal* in *equal* Times.—For, if the Times in which the *Planet* moves from A to B, and from B to C, and from C to P, be *equal* to each other, as, suppose, a *Day*, a *Week*, a *Month*, &c. the *Areas*, or *triangular* Spaces, ASB, BSC, and CSP, describ'd in those *equal* Times, (by Lines drawn from the *Planet* to the *Sun*) will also be *equal* among themselves, or to one another.—It must therefore follow, that when the *Planet* is near its *Perihelion*, its Motion will be so much *swifter* than in the *Aphelion*, as the Line PS is shorter than AS; because the Line PS multiply'd into the Arch PC, must be equal (by this surprising Law) to the Line SA multiply'd into the Arch BA.



Though the *Planets* revolve at different Distances, one beyond the other, round the *Equatorial* Parts, or *Middle* of the *Sun*, yet they do not all move exactly in the same *Plane*; but have their Orbs a little *inclin'd* to one another.—Thus, suppose we make the Plane of the *Earth's* Orbit the Standard, then we shall find that the Orbits of the rest of the *Planets* cut it in *two* opposite Parts; having one Half of their Orb above, the other Half below it. The Points where the Orbits cut the Plane of the *Earth's* Orbit, are call'd the *Nodes* of the *Planets*. No *Planet* can therefore be in the *Ecliptic* (i. e. exactly level with the Plane of the *Earth's* Orb) but when it is in the *Nodes*: In all other Parts they are either a little *above* or a little *below* it. When they are *above* it, they are said to have *North Latitude*; when *below* it, *South Latitude*; which *Latitude* is never but a few Degrees. For when the *Planets* are at the greatest Distance *above* or *below* the Plane of the *Earth's* Orbit, (which always happens when they are in the Middle between the *Nodes*) the Distance of *Saturn* is not more than  $2\frac{1}{2}$  Degrees; of *Jupiter*,  $1\frac{1}{4}$  Degree; of *Mars*,  $1\frac{3}{4}$  Degrees; of *Venus*,  $3\frac{1}{2}$  Degrees; and of *Mercury*, 7 Degrees.—This *Inclination* seems to have been given the *Planets* to prevent their too frequently *eclipsing* one another; which they would have done every Revolution, had not this Divine Contrivance taken Place.



To give the Learner a better Idea of the various *Properties* and *Affections* of the *Planets* mentioned in the foregoing Course of this Work, I have brought them all into one View in the following TABLE.

Planets Names	Saturn	Jupiter	Mars	Earth	Venus	Mercury
Characters or Marks	♄	♃	♂	♁	♀	☿
Diameters in Miles	67870	81155	4444	7964	7906	2460
Circumfer. of Bodies	213112	254908	13960	25020	24823	7724
Mean Distance from the Sun, in Miles	777000000	424000000	123000000	81000000	59000000	32000000
Periods, or Length of their Years	10759 <sup>d</sup> 6 <sup>h</sup> 36 <sup>'</sup>	4332 <sup>d</sup> 12 <sup>h</sup> 20 <sup>'</sup>	686 <sup>d</sup> 23 <sup>h</sup> 27 <sup>'</sup>	365 <sup>d</sup> 6 <sup>h</sup> 9 <sup>'</sup>	224 <sup>d</sup> 16 <sup>h</sup> 49 <sup>'</sup>	87 <sup>d</sup> 23 <sup>h</sup> 16 <sup>'</sup>
Diurnal Motion, or Length of their Days	unknown	0 <sup>d</sup> 9 <sup>h</sup> 56 <sup>'</sup>	1 <sup>d</sup> 00 <sup>h</sup> 40 <sup>'</sup>	0 <sup>d</sup> 23 <sup>h</sup> 56 <sup>'</sup>	0 <sup>d</sup> 23 <sup>h</sup> 00 <sup>'</sup>	unknown
Moons, or Satellites	5	4	unknown	1	suppos'd 1	not known
Proport. of Light and Heat, supposing the Light at the Earth 1	$\frac{1}{90}$	$\frac{1}{27}$	$\frac{4}{10}$	1	2	7
Inclination of their Orbits to the Ecliptic	2° 30' 00"	1° 20' 00"	1° 52' 00"	0° 00' 00"	3° 24' 00"	6° 54' 00"
Inclination of their Axes to their Orbits	30° 00' 00"	little if any	little if any	23° 29' 00"	little if any	unknown
Daily mean Motion in the Ecliptic	0° 02' 00"	0° 04' 59"	0° 31' 27"	0° 59' 08"	1° 36' 08"	4° 05' 32"
Greatest appar. Diam.	0' 19" 40'''	0' 24" 12'''	0' 20" 50'''	32' 47" Sun	1' 05" 58'''	0' 11" 48'''
Least apparent Diam.	0' 14" 11'''	0' 14" 36'''	0' 12" 46'''	31' 40" Sun	0' 09" 34'''	0' 04" 04'''
Eccentricity of Orbits, supposing Dist. 1000	55	48	93	17	7	210
Place of Aphelion, the Perihelion opposite	♊ 0° 06'	♈ 10° 58'	♋ 1° 55'	♏ 8° 57'	♍ 7° 37'	♌ 13° 45'
Place of Ascend. Node, Descending opposite	♍ 21° 26'	♍ 8° 32'	♋ 18° 09'	* * *	♈ 14° 34'	♋ 15° 45'
Elongation of Inferior, and Parallax of Superior Planets	6° 00'	11° 05'	41° 00'	* * *	46° 41'	22° 46'
Colours of the Planets	dim lead-colr.	splendid white	fiery red	* * *	yellowish wh.	sparkl <sup>g</sup> . red
Motion in an Hour, in Miles	18000	24000	45000	56000	70000	100000

The *Distance* of the *Moon* from the *Earth* is about 240.000 Miles.—She revolves round her Orbit, from *Sun* to *Sun*, in 29<sup>d</sup> 12<sup>h</sup> 44<sup>'</sup>.—Her *Diameter* is 2170, and her *Circumference* 6815 Miles.—The *Length* of their *Day* is almost 30 of ours, and their *Year* the same as with us.—She moves in one Hour 2200 Miles.—Greatest *apparent Diameter* 33' 20", and *least* 29' 48".—The *Place* of the *Nodes* is always varying, revolving round the *Ecliptic* in 18<sup>y</sup> 224<sup>d</sup> 4<sup>h</sup>.—Her *Eccentricity* is 55 Parts in 1000.—The *Moons* of *Jupiter* and *Saturn* are suppos'd to be as large as our *Moon*, or some of the *Inferior Planets*.

Of all the *Comets*, the *Periods*, *Distances*, &c. of only *Three* of them are known.

1 <sup>st</sup> Comet	} revolves in	Years	} at the Rate of	Miles	} in an Hour.	Greatest Distance from Sun	Miles.	} Least Dist.	Miles
2 <sup>d</sup> Comet		75		13000			2916 Mill.		48000000
3 <sup>d</sup> Comet		129		9000			4050 Mill.		40000000
		575		6000			11200 Mill.		500000

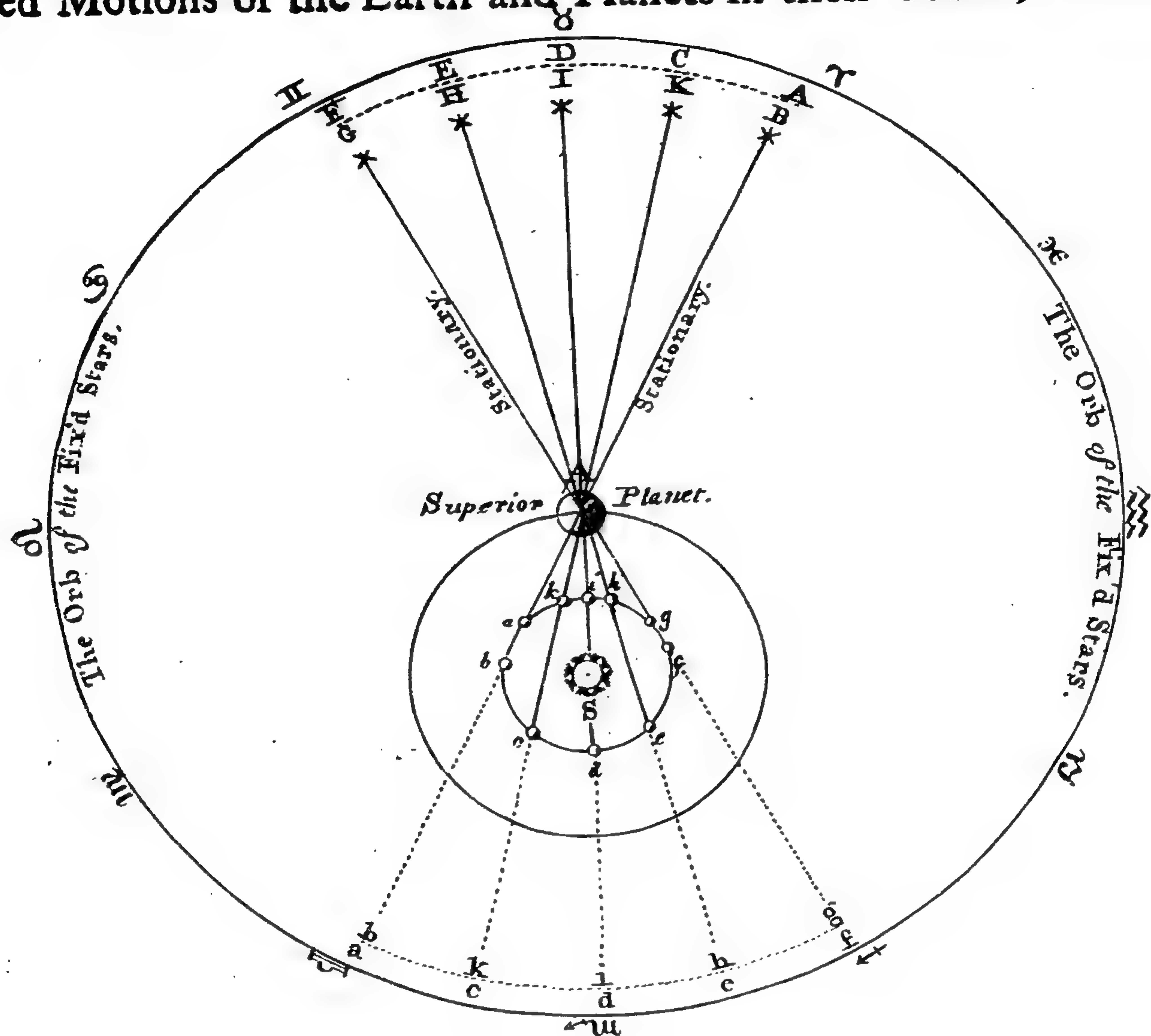
Some *Comets* are as *small* as the *Moon*, and others as *large* as our *Earth*.

The *Distance* of the nearest *fix'd Star* is about 2.200.000.000.000 Miles; and they seem to make one *Revolution* on the *Poles* of the *Ecliptic* in 25920 *Years*.



# STATIONS AND RETROGRADATIONS Of the PLANETS.

**I**F the *Planets* were viewed from the *Sun*, they would always appear to move round him *direct*, and according to the Order of the *Signs*, i. e. from *Aries* to *Taurus*, &c. but to us, who see them from the *Earth*, they appear sometimes to move on *direct*,—sometimes to be *retrograde*, or run back,—and sometimes to be *stationary*, or fixed to one particular Point in the Heavens. This *Diversity* of their *Appearances*, is owing to the united Motions of the *Earth* and *Planets* in their Orbits, as here delineated.



In this *Scheme*, let S represent the *Sun*, the Center of the *System*;—the smaller Circle *a, b, c, d*, &c. the Orbit of the *Earth*;—and the larger the Orbit of one of the *superior Planets*;—also let the outer Circle  $\gamma, \delta, \pi$ , &c. represent the Orb or Sphere of the *fix'd Stars*, where the Place and Motions of the Planets are determined. Then it is evident, that tho' the *Planets* all revolve round the *Sun* the *same Way*, and with a regular Velocity, yet to us on the *Earth* (and to one another) their Motions will seem very different. For sometimes they will appear to move *slowly*, sometimes to *stand still*, and at other Times to *run back*, or move contrary to their real Motions. Thus, suppose the *Earth* in her Orbit at *a*; then an Eye will behold the *superior Planet A* (suppose it be *Saturn*) in the Line continu'd from the *Earth*, by the *Planet*, to the *Stars* at *A*.—All the Time the *Earth* passes from *a* to *b*, the *Planet* will appear to *stand still*, or fix'd in the same Part of the Heavens, because the Line proceeding from the *Earth* to the *Planet* continues the same.—As the *Earth* moves from *b* to *c*, the *Planet* will appear to move from *B* to *C*, with a *direct* Motion among the *Stars*, also.—At *D*, he is said to be in *Conjunction* with the *Sun*, i. e. in the same Place of the Heavens with that *Luminary*; and, if in the *Plane* of the *Ecliptic*, will pass behind his *Disk*, and rise and set when he does.—As the *Earth* goes on to *e* and *f*, the *Planet* will be seen to move *direct* to *E* and *F* likewise: But whilst the *Earth* passes from *f* to *g*, the *Planet* will appear to be *stationary*, or not to move at all.—And as the *Earth* revolves to *h*, the *Planet* will seem to *run back* to *H*.—At *i*, he will appear at *I*; where he is said to be in *Opposition* to the *Sun*; he now rises as the *Sun* sets, and shines.



shines all the Night.—As the *Earth* proceeds to *k*, the *Planet* continues to go *retrograde*; and when the *Earth* is come to *a*, the *Planet* becomes *stationary* as at first.

From this Scheme it is also evident that the same Appearances must happen to the *inferior Planets* as to the *superior*. For an Inhabitant at the *superior Planet* at *A*, will see the *inferior* move on *direct*,—become *stationary* and *retrograde*, at the same Time, and in the same Manner, but in the *opposite* Part of the Heavens.—Thus, whilst the *superior Planet* is beheld from the *inferior*, at *a* and *b*, to be *stationary* at *AB* in  $\gamma$ , the *inferior* will be seen from thence *stationary* at *ab* in  $\alpha$ .—When the *inferior* is at *c*, he will appear, in the opposite Part at *c*.—At *d*, he will appear at *d*, *conjoin'd* with, and in the same Part of the Heavens with the *Sun*. This Situation of an *inferior Planet*, because it is situate beyond the *Sun*, is call'd its *superior Conjunction*; and, if it has no *Latitude* at that Time, will pass behind the *Sun's* Body, and suffer an *Eclipse*.—As he advances from *d* to *e*, he appears, from *A*, to move on still *direct* from *d* to *e*.—At *f*, he is seen at *f*, where is his *greatest Elongation* on that Side his Orbit from the *Sun*, and will set in the Evening after him.—Whilst the *inferior* moves from *f* to *g*, he appears *stationary*, and (as it were) fix'd in the same Part of the Heavens, just as the *superior* does from thence in the *opposite* Parts; because the Lines, passing from each to each, terminate in the same Places during that Time.—But, as he proceeds from *g* to *h*, he appears to the *superior* (as the *superior* does to him) to go back, or *retrograde* in the Heavens.—At *i*, he will be found at *i*, *conjoin'd* with the *Sun* again. This is call'd his *inferior Conjunction*, because between the *superior* and the *Sun*; and, if he is exactly in the Plane of the *Ecliptic*, will pass over the *Sun's* Disk, and appear like a *black Spot* on his Face.---As he revolves from *i* to *k* and *a*, he still recedes *backwards*, and appears, amongst the Stars, at *k* and *a*.---From *a* to *b* he appears *stationary*, as well as the *superior*, and for the same Reasons as they did, on the other Side of the Orbit, at *f* and *g*.---At *a* he is said to be at his *greatest Elongation* on this Side the *Sun*, and sets before him.---At *b* he begins to move *direct* as before.

I have considered the *superior Planet* as remaining in the same Part of its Orbit during one Revolution of the *Earth*, in order to convey the Ideas of their *Stations*, *Directions*, and *Retrogradations* easier to the Learner. For tho' they actually advance, at the same Time, the same Way, but as the Motion of the *superior* is much *slower*, it may, in this Illustration, be safely omitted. For Instance, while the *Earth* revolves once round, *Saturn* will have gone but one thirtieth Part of his Orbit; *Jupiter*, in the same Time, would have gone about one twelfth Part; and *Mars* still further.---Whence it follows, that these *Appearances* happen oftener in *Saturn* than in *Jupiter*; and oftener in *Jupiter* than in *Mars*; because the *Earth* sooner overtakes (or comes up with) the former Planets than the latter, whose Motion is faster. And, for the same Reason, they happen oftener in *Mercury* than in *Venus*, because he circulates not only faster, but in a less Orbit, and therefore oftener overtakes the *Earth*. These *Retrogradations* are greater, the nearer the Planets are to the *Earth*.

☞ If two Planets are on the *same Side* the *Sun*, they appear *retrograde* to each other;--if, on the *contrary Side*, they always appear *direct*;--but for some *little Time* before and after their *Conjunctions*, they appear *stationary*. This is an undeniable Proof of the *Earth's* Motion, and that the present *System* is the *true System of the World*: Because, if the *Earth* be suppos'd to remain fix'd in the Center of the Universe, these various Motions could never take Place here; but all the Planets would appear to move (as they really do) *the same Way*, and revolve (like the *Moon*) regularly round us.

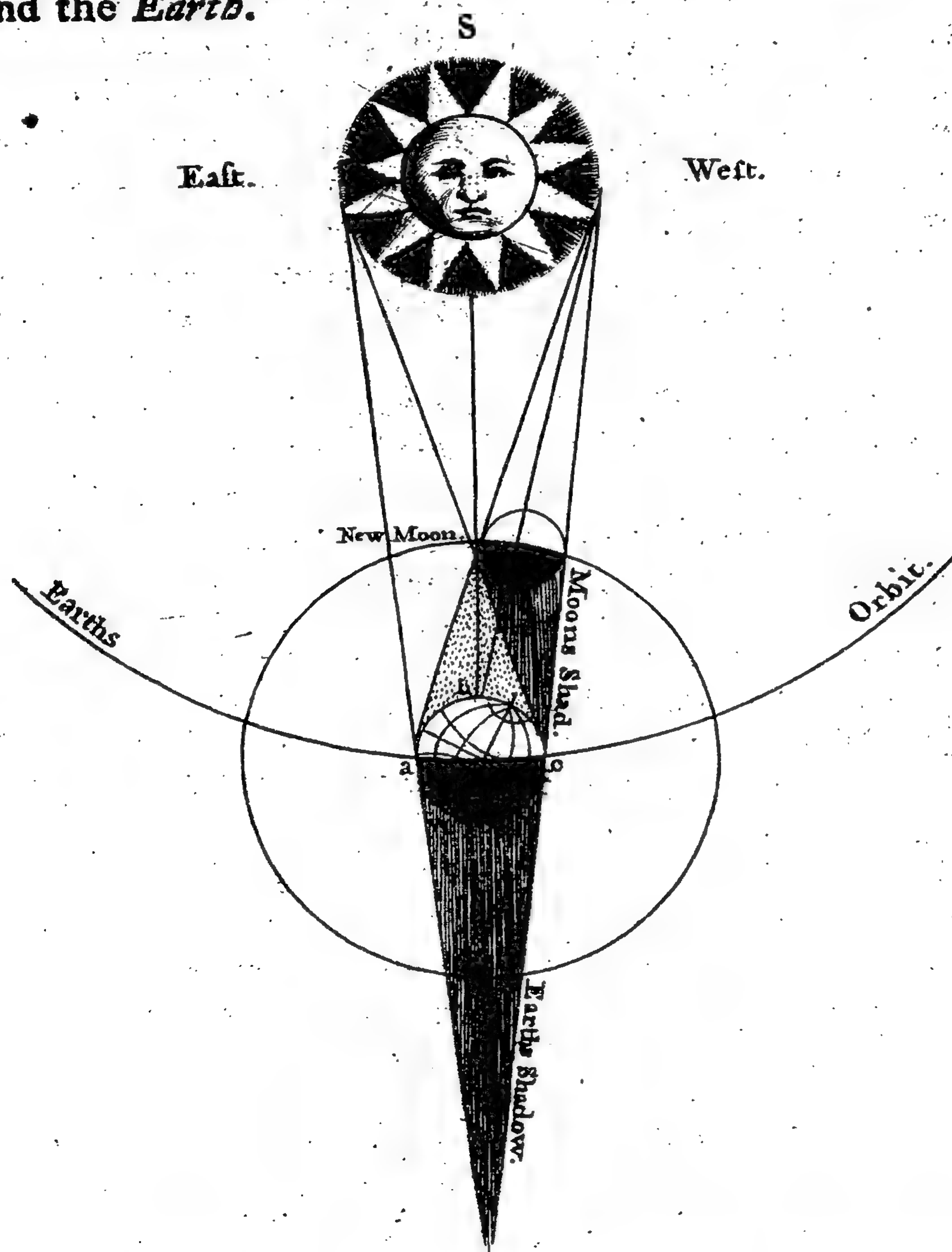


# A SHORT SYSTEM OF Of ECLIPSES.

**A**N *Eclipse* is that *Obscuration*, or *Deprivation* of *Light*, in any of the heavenly Bodies, caus'd by some other coming between the *Sun* and that Body. There are various Kinds of *Eclipses* in the Heavens, but those of the *SUN* and *MOON* are most remarkable.

## ECLIPSE of the SUN.

**T**HE *Eclipse* of the *Sun* (or more truly of the *Earth*) is caus'd by the *Moon*, as she revolves in her Orbit, coming between the *Sun* and *Earth*, and by that means hiding his Light from us. This can never happen but at the *New-moon*, as is evident from an Inspection of the following Scheme; in which S represents the *Sun*, E the *Earth*, and M the *Moon* in her Orbit revolving round the *Earth*.



Now, when the *Moon* is come in Conjunction with the *Sun*, i. e. just between *Us* and *Him*, which can never happen but at the *New-moon*, it is manifest that her Shadow will fall upon the *Earth* at *a*, and thereby hide his Face and Light from those who live upon that Spot. But as the *Moon* is much less than the *Earth*, the Shadow of the *Moon* cannot cover the whole but only Part of the Surface next it. For this Reason, you see that the same *Eclipse* of the *Sun* may be total to one Country;—to another *partial*, or Part eclips'd:—and to a third, none at all.

Thus



Thus, in the above Scheme, it is manifest that to the Inhabitants of that Part of the *Earth* marked *a*, the *Sun* will seem to be *totally* dark, they being wholly involv'd in the Shadow.—To those at *b*, he will appear to be eclips'd in *one Part only*, and the more so the nearer the Spectator is to *a*, they being immers'd only in the *partial* Shadow.—And to those that live at *c*, he will not be eclips'd at all\*.—At the same Time, an Eye at the upper Part of the *Moon*, will see the *Sun* free from any Obscurity, whilst those on the under Side will behold the *Earth*, Part of it, involv'd in a  *dusky* Shade.

The *Sun's Eclipse* always begins on the *West*, and ends on the *East* Side his Body. The Reason is, because the *Moon*, which is always the Cause of this Obscurity, moving round her Orbit from West to East, must necessarily first arrive at, and touch the *Sun's* Western Limb, and go off at the Eastern.

As the *apparent* Diameters of the *Sun* and *Moon* are nearly equal, the total Duration of an *Eclipse* of the *Sun* can never continue more than *two Minutes*; but the same *solar Eclipse*, from *Beginning* to *End*, may be  $2\frac{1}{4}$  Hours.

In order to determine the Quantity of an *Eclipse*, *Astronomers* have divided the *Sun's Diameter* in 12 equal Parts, call'd *Digits*; and therefore, when they say the *Sun* will be eclips'd 5 or 6 *Digits*, they only mean, 5 or 6 *Fingers* Breadths of the *Sun* will be obscur'd or darken'd, whilst the rest will continue bright and visible to the Spectator.

An *Eclipse* of the *Sun* can only be visible by *Day*, when the *Sun* is above the *Horizon*: And though there be 12 *New-moons* every Year, yet it is seldom we have more than 4 *Eclipses* of the *Sun*, the Reason of which will be shewn 2 or 3 Pages further on.

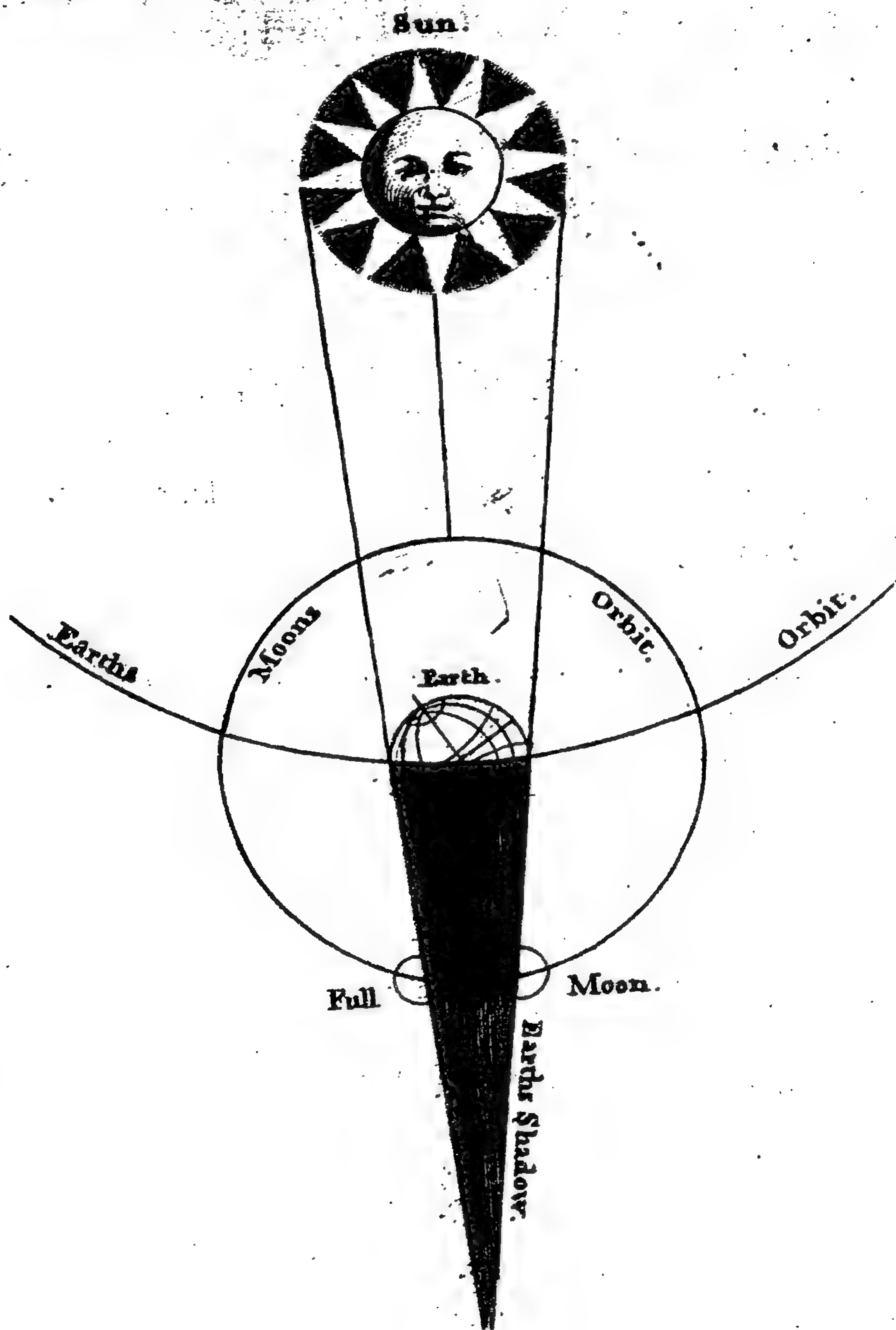
\* The Shadow of the Moon will cover a greater or less Portion of the Earth's Surface, as the Moon happens to be nearer or further from us at the Time of the Eclipse. At a mean, the shadow may spread itself over 180 Miles in Diameter, and move at the Rate of 2104 Miles in an Hour. But the *partial* or *penumbral* Shadow will extend the Breadth of 4900 Miles; and be five Hours in passing over the Earth's Disk.

☞ In the early Ages of the World, the Nature and Cause of *Eclipses* was so little known, that the Ignorance and Superstition of those Times looked on them as Prodiges, and portentous of some great and malevolent Effects: But the Learning of the present Age has taught us, that these Appearances happen according to the Course of Nature, and are the necessary Result of those Laws which the Divine Being gave them at the Creation.—*Ricciolus*, in his *Almagest*, relates a Story of *Columbus*, who being drove on Shore at the Island of *Jamaica*, in 1493, and meeting with great Distress and Cruelty from the barbarous Inhabitants, threaten'd to afflict them with some grievous Calamity; assuring them, as a Mark of his Power, that on such a Day the *Sun* should be darken'd; which, by an *Eclipse*, happen'd on the Day he had assigned. This surprising Phenomenon wrought such Terror in their Minds, that they look'd on him as something more than human; and, therefore, they afterwards did all in their Power to serve him.



## ECLIPSE of the MOON.

**A**N *Eclipse* of the *Moon* is caus'd by the Interposition of the *Earth* between the *Sun* and *Moon*: This can only happen at the *Full-moon*, when she is directly opposite the *Sun*; for the *Earth*, being then exactly between the *Sun* and the *Moon*, will cast her Shadow upon the *Moon*, just as the *Moon* did her Shadow upon the *Earth* before, in the *Eclipse* of the *Sun*. This is clear from a Sight of the following Figure; where it is evident, that when the *Moon* is arriv'd to the opposite Part of her Orbit, she falling, more or less, into the *Earth's Shadow*, is by that Means depriv'd of her Light from the *Sun*, and so suffers an *Eclipse*.



If only Part of the *Moon's* Body passes through the *Earth's Shadow*, she is said to suffer a *partial Eclipse*.—If the *whole Body* is immers'd in the *Shadow*, and begins immediately to emerge again, the *Eclipse* is said to be *total without Continuance*.—But if the *Moon* passes through the *Middle* of the *Shadow*, (or near it) her Stay there will be considerable; as the *Shadow*, in that Part of it, is about three Times broader than the *Moon*, and the *Eclipse* will be *total with Continuance*.



An *Eclipse* of the *Moon* appears to all Parts where it is visible to be the same in *Quantity* and *Duration* as it really is. For the *Moon* being an *opaque* Body, shining only with a reflected Light from the *Sun*, is depriv'd of that Light by being immers'd in the *Earth's Shadow* \*.

The *Moon's Eclipse* begins always on the *East* Side, and ends on the *West*, contrary to that of the *Sun*. For her *Eclipse* being *real*, and by Reason of her direct Motion always *Eastward*, the *Eastern* Part of her Body must necessarily first touch the *Earth's Shadow*, and the *Western* Part leave it last.

The *Shadow* of the *Earth*, where the *Moon* passes through it, being almost three Times as large as the *Diameter* of the *Moon*, it will often happen, that *total Eclipses* of the *Moon* may be of very different Lengths; but it is seldom that *total Darkness* continues more than  $1\frac{1}{2}$  Hour, or the *whole Eclipse*, from Beginning to End, more than  $3\frac{1}{2}$  Hours.

The Body or Disk of the *Moon* is suppos'd to be divided (like that of the *Sun*) into twelve equal Parts, or *Digits*; and as many as are the Parts immers'd in the *Earth's Shadow*, so many *Digits* is the *Moon* said to be eclips'd. But as the *Diameter* of the *Shadow* is far greater than the *Diameter* of the *Moon*, it must follow, that, when the *Moon* is immers'd in the Middle of the *Shadow*, not only the twelve *Digits* are eclips'd, but there remains a considerable Part of the *Shadow* to be pass'd thro' still. In *Lunar Eclipses*, therefore, which are total, we reckon the Number of *Digits* according to the Quantity of the *Earth's Shadow* over, or beyond the *Moon*, when it is immers'd wholly in the *Shadow*, which may sometimes extend to 23 *Digits* nearly.—All above 12 shew how many Parts of the *Shadow* the *Moon* has to pass thro' before she begins to appear on the opposite Side.

The *Moon's Eclipse* is visible only by *Night*, i. e. when she is above the *Horizon*: And though we have twelve *Full-Moons* within the Circle of the Year, yet never more than three of them suffer an *Eclipse*. The Reason you will find in the next Pages.

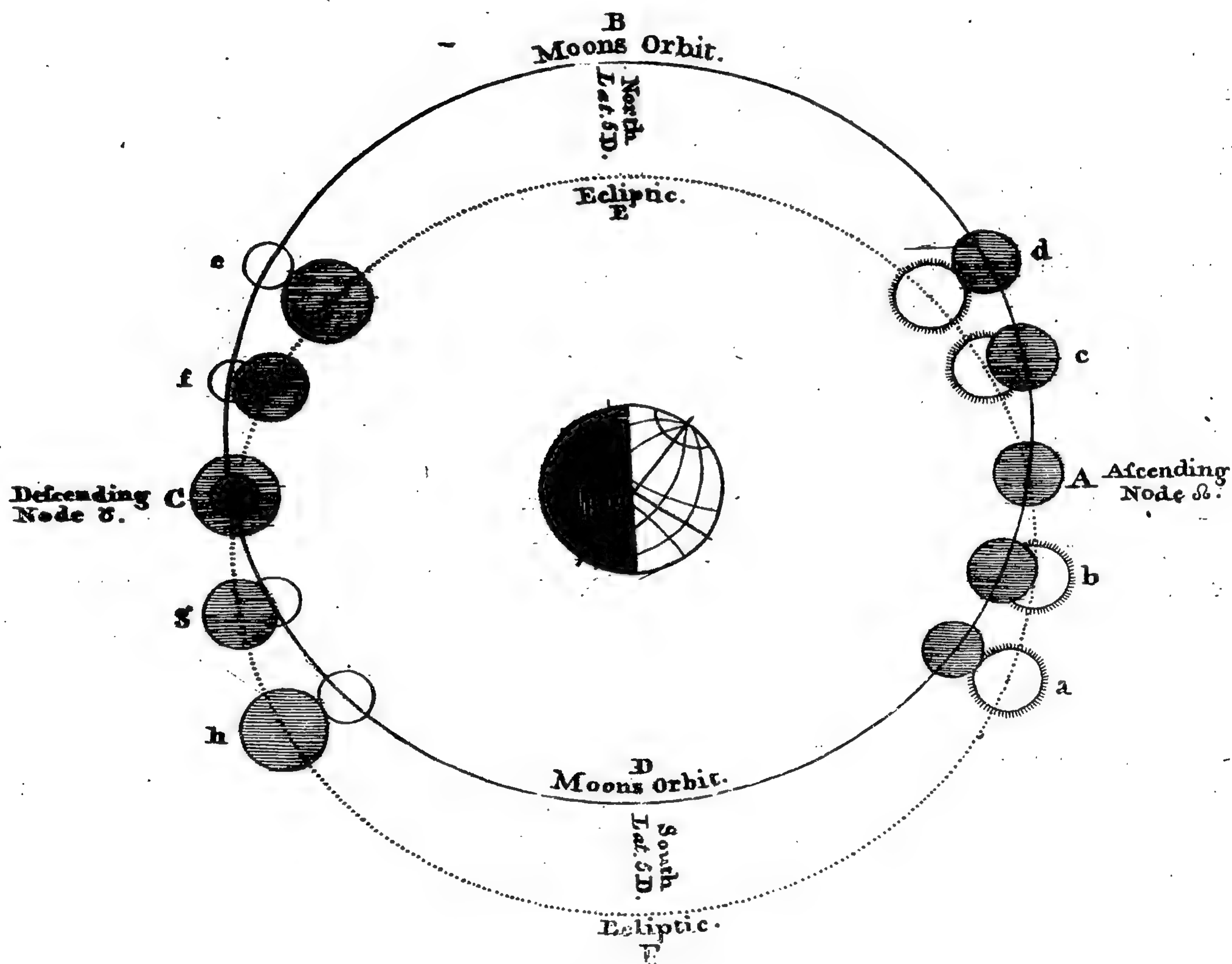
\* In *total Eclipses* of the *Moon*, when she is in or near the Center of the *Earth's Shadow*, her Body is frequently seen of a languid swarthy Colour: This is owing not to any Light she has in herself, but to the Rays of the *Sun* falling into our *Atmosphere*, which being thereby refracted, are bent out of their direct Course into the *Shadow*: These Rays falling upon the *Moon*, when she is even in the Middle of the *Shadow*, render her visible to the Spectators at that Time.

☞ From the Writings of the Apostles we learn, That at our Saviour's Crucifixion there was *Darkness over all the Land from the sixth to the ninth Hour*, i. e. from 12 to 3 in the Afternoon; which *Darkness* some Persons may, perhaps, attribute to an *Eclipse* of the *Sun*. But that is impossible: For *Christ* suffer'd at the Time of the *Jewish Passover*, which was always celebrated at the *Full-moon*, when these two Luminaries are in Opposition to, and at their greatest Distance from each other. Besides, such uncommon *Darkness* could not happen from any *natural Eclipse* of the *Sun*: For, as the apparent *Diameters* of those two Planets are nearly equal, such *Eclipse* could not last but a few Minutes, whereas this *Darkness* lasted about three Hours.—*Dionysius*, a Judge of *Areopagus*, near *Athens*, being at *Heliopolis*, and observing this *præternatural Phenomenon*, cry'd out, that *Nature was dissolving, or the God of Nature suffers*. He afterwards embrac'd the Christian Faith (from this Astronomical Conviction), and suffer'd Martyrdom for the Truth of it.



## Of the LIMITS of ECLIPSES both SOLAR and LUNAR, with the *yearly Number* of each, and the *Times* when they happen.

**T**HE Reason why the *Sun* is not eclips'd at every *New-moon*, nor the *Moon* at every *Full*, is because the *Moon's Orbit* does not lie in the same Plane or Tract with that of the *Earth's*, which is call'd the *Ecliptic Line*, but cuts or crosses it in two opposite Points, making an Angle therewith of about 5 Degrees. These two Points or Intersections are call'd the *Nodes* of the *Moon*. The Point where the *Moon* begins to ascend above, or become Northward of the *Ecliptic Line*, is call'd the *ascending Node*, and is usually mark'd by *Astronomers* thus (♌). The other Point, from which the *Moon* begins to descend below, or go Southward of the *Ecliptic*, is call'd the *descending Node*, and is mark'd thus (♍). See the following Scheme.



In this Scheme, let the larger black Circle, ABCD, represent the *Moon's Orbit* with the *Earth* in the Center: And let the dotted one, AEFC, represent the *Ecliptic*, or Plane (at the Distance of the *Moon*) in which the *Sun* and *Earth's Shadow* appear to move. Then will A and C be the two *Nodes*, or Knots where the *Moons' Orbit* and *Ecliptic* intersect each other in an Angle (at A and C) of 5 Degrees; one *half* of the *Moon's Orbit*, ABC, being above the *Ecliptic*, the other *half*, CDA, below it. The little Suns upon the dotted Circle, about the Node A, represent the *Sun* in those Parts of the *Ecliptic*; and the little shaded Circles are the *New-moons*, at those Places also. — On the opposite Side, the

black



black Circles represent *Sections* of the *Earth's Shadow*, which are always opposite the *Sun*; and the lighter Circles are the *Moons*, which happen there at the *Full*.

Now, suppose the *Moon*, in passing round her *Orbit* (which she does every Month), comes into *Conjunction* with the *Sun* at *a*, where she is below, or Southward of the *Ecliptic Line*, then it is apparent (from the Figure) that her *upper Limb* will just touch the *Sun's lower Limb*, without eclipsing it.—But if the *New-moon* happens at *b*, then the *Moon* will pass over the lower Part of the *Sun's Disk*, and cause an *Eclipse*.—If at the Time of the *New-moon*, the *Moon* meets with the *Sun* in the very *Node*, at *A*; then there will happen a *central* and *total Eclipse* of the *Sun*. But as their apparent *Disks* are nearly equal, the *total Darknefs* will continue but two or three Minutes at most.—If the *New-moon* happens at *c*, then you see there will be a *partial Eclipse* of the *Sun*; and the *Sun's upper Part* will be obscur'd, as the *Moon* is now got Northward, or above the *Ecliptic Line*.——If the *Luminaries* meet at *d*, then the *Moon's lower Limb* will touch the *Sun's upper Limb*, but pass by without eclipsing him.

Again; As the *Moon* passes from the *Sun* to the opposite Part of her *Orbit*, where she is in the *Full*, as at *e*, then her *lower Limb* will just touch the *Edge* of the *Earth's Shadow*, but pass over it without being, in any Part, eclips'd.—But if the *Full-moon* happens nearer the *Node*, at *f*, then the *lower Part* of the *Moon* dips into the *Shadow*, and causes a *partial Eclipse*.——But if the *Full-moon* falls at the very *Node C*, the *Moon* passing there thro' the *Middle* of the *Shadow* will be *totally* and *centrally eclips'd*; which *Eclipse* will be of some Continuance, as the *Shadow* is, in that Part, nearly three Times the Diameter of the *Moon's Body*.——If the *Opposition*, or *Full-moon* happens at *g*, then there will be a *partial Eclipse*; but the *upper Part* of the *Moon* will be immers'd in the *lower Part* of the *Shadow*, because she is now descended below the *Ecliptic*.——At *h*, the *Moon's full Disk* passes under the *Shadow* free from any Obscuration.

The *Distance* of the *Moon*, in *Degrees* and *Minutes*, above or below the *Ecliptic Line*, is call'd her *Latitude*, If she is above the *Ecliptic*, she is said to have *North Latitude*; if below it she has *South Latitude*: And if the *Latitude*, at any Time, exceed the Sum of the *Semidiameter* of the *Moon* =  $16\frac{1}{4}$  Minutes, and the *Earth's Shadow* =  $45\frac{1}{4}$  Minutes, the *Moon*, at that Time, cannot be eclips'd; but will either pass under or over the *Shadow*, just as she happens to be above or below the *Ecliptic Line*.—The *Distance* from the *Node*, either before or after it, corresponding to the above *Latitude*, is about 12 Degrees; consequently, that is the Limit of *Lunar Eclipses*. For, when a *Full-moon* happens within 12 Degrees of the *Node*, then she will be eclips'd; and the nearer the *Node*, the greater will the *Eclipse* be.

If at the *New-moon*, the *Latitude* of the *Moon* exceeds the Sum of the *Semidiameters* of the *Sun*, =  $16\frac{1}{4}$  Minutes, and the *Moon*, =  $16\frac{1}{4}$  Minutes, we should see no *Eclipse* of the *Sun*, if beheld from the *Center* of the *Earth*:

But



But as we view the Luminaries from the *Surface*, which is much higher, we are obliged to take in the *Semidiameter* of the *Earth* likewise, =  $6\frac{1}{4}$  Minutes. Then, I say, if the Latitude of the *Moon* be greater than the Sum of these three Numbers. =  $94\frac{1}{4}$  Minutes, the *Sun* will not be eclips'd; for the *Moon* will pass either over or under his *Disk*, according as she is above or below the *Ecliptic Line*. — The Distance from the *Node*, on either Side it, agreeing to this Latitude of the *Moon*, is about 18 Degrees, which is the utmost Limit of *solar Eclipses*: Whence it follows, that if the *Sun* and *Moon*, at the Time of *New-moon*, happen to be within 18 Degrees of the *Node*, the *Sun* will suffer an *Eclipse* at that Time, and the greater the nearer they are to the *Node*.

If the *Sun* should happen to be eclips'd on one Side the *Node*, just within the Limit between *a* and *b*; then the following *Full-moon* will be eclips'd, but not in the opposite Degree of the *Ecliptic*, but something nearer the *Node C*; because the *Earth's Shadow* is advanc'd about 14 Degrees forwarder in the *Ecliptic* in that Time. And the returning *New-moon* will overtake the *Sun*, and eclipse him again, somewhere between *c* and *d*. — But if an *Eclipse* of the *Sun* happen at, or near the *Node A*, then the following *Full-moon* will not arrive at the *Earth's Shadow* (which is still moving forward) till it is beyond the *ecliptic Boundary* at *b*; so that there can be no *Eclipse* at that *Full*. — The other *New* and *Full-moons* will pass without being productive of any *Eclipse*, till the *Sun* arrives to the opposite *Node C*; where the same Number and Kind of *Eclipses*, which fell at the former *Node*, will fall again at this. For the *Sun* and *Earth's Shadow* having only chang'd Places, the same *Eclipses* must be repeated, in the same Manner, and for the same Reasons, as before. Hence it is manifest, that there can never happen more than six *Eclipses* in any Year, i. e. two of the *Sun* and one of the *Moon* at each *Node*; nor less than two, i. e. one of the *Sun* at each *Node*, without any *Lunar one*.

As *Eclipses* only happen in those Months in which the *Sun* enters the Signs where the *Moon's Nodes* are situate; and as the *Nodes* are directly opposite, the Times of *Eclipses* will happen at opposite Parts of the Year. Thus, if any *Eclipse* happens in January or February, then will also happen another in June or July; the *Sun*, in those Months, being in Signs of the *Ecliptic* opposite to one another.



# Of the PERIOD of ECLIPSES, Both SOLAR and LUNAR.

**I**F the Places of the *Nodes* were fix'd, *Eclipses* would always happen nearly at the same Seasons of the Year: But as they have a Motion of about 3 Minutes 11 Seconds every Day backwards in the *Ecliptic*, or contrary to the Order of the *Signs*, i.e. from *Aries* to *Pisces*, &c. the succeeding *Eclipses* must recede backwards, from *March* to *February*, likewise: And in one Revolution of the *Nodes*, which is in 18 Years, 224 Days, 3 Hours, they will revolve in a *retrograde* Manner thro' the Year, and return to the same Places again.

But there is a more correct *Period* of *Eclipses* discover'd by Observation; which is 18 Years, 11 Days, 7 Hours, and 43 Minutes: For, in that Time, the *Sun* and *Moon* advance just as far beyond a compleat *direct* Revolution in the *Ecliptic*, as the *Nodes* want of completing their *retrograde* one. Consequently, as the *Sun* and *Moon* meet the *Nodes* at the End of that Period, the same *solar* and *lunar* *Aspects*, which happen'd 18 Years, 11 Days, 7 Hours, and 43 Minutes ago, will *return*, and produce *Eclipses* of both *Luminaries*, in *Number* and *Quantity* the same as before.—On this *Principle* the following *Table* and *Calculations* are constructed.

✱ The same Kind of *Eclipses* happen to *Jupiter* and *Saturn*: But as *Jupiter* has four *Moons*, and *Saturn* five, and as their *Revolutions* are much quicker than ours, *Eclipses* must happen more frequently there than here.

The USE that may be made of ECLIPSES is very great, not only to the *Astronomer* and *Chronologist* in ascertaining more accurately the Periods of the Planets, and fixing the antient Accounts of Time, but to the *Geographer* and *Mariner* in determining the LONGITUDE of Places at *Sea* or *Land*. For having an *Eclipse* truly calculated to any particular *Meridian*, as suppose *London*, where the *Eclipse* is found by Calculation to begin at 5<sup>h</sup> 32<sup>m</sup>, in the Afternoon; and being at *Sea*, the same *Eclipse* is observ'd to begin at 6<sup>h</sup> 16<sup>m</sup>, the Difference, which is 44<sup>m</sup>, turn'd into Time, allowing for every 4 Minutes 1 Degree, makes 11 Degrees, and so much is the Observer to the *Eastward* of *London*.—— But if the Time had been found to be *sooner* than by the Calculation, then is the Person so much to the *Westward* of *London*. By this Discovery the *Mariner* is enabled to pass with greater Safety thro' the Surface of the *path's* Deep, for by knowing where he is, he knows the better how to evade the Dangers, and to direct his Course to the wish'd for Port.



## A TABLE OF ECLIPSES,

So adapted, that the *young Astronomer* may, with very little Trouble, calculate the Number of Eclipses in any Year; discover whether they are of the Sun or Moon; with the Quantity eclips'd; and the exact Time of the Day or Night they fall on.

	Mon.	D	H	M	Lat. D	Lum.		Mon.	D	H	M	Lat. D	Lum.	
Leap 1744	Apr.	1	9	51	0 39 SD	Sun	1754	Mar.	12	10	12	1 20 ND	Sun	
	Apr.	15	8	32	0 35 SA	Moon		Mar.	26	19	47	0 2 SD	Moon	
	Sept.	24	13	18	0 44 ND	Sun		Apr.	11	2	45	1 19 SA	Sun	
	Oct.	10	0	48	0 40 NA	Moon		Sept.	5	4	43	1 20 SD	Sun	
1745	Mar.	21	14	56	0 2 NA	Sun	1755	Sept.	19	22	28	0 1 ND	Moon	
	Sept.	14	5	20	0 1 ND	Sun		Oct.	4	13	31	1 17 NA	Sun	
1746	Feb.	24	3	4+	0 37 ND	Moon		Mar.	1	9	45	0 40 ND	Sun	
	Mar.	10	14	54	0 42 NA	Sun		Mar.	16	12	12	0 42 NA	Moon	
	Aug.	19	12	5	0 39 SD	Moon	Aug.	25	20	30	0 37 SD	Sun		
	Sept.	3	21	22	0 43 SA	Sun	Sept.	8	22	40	0 34 SA	Moon		
1747	Jan.	29	2	52	1 21 SD	Sun	Leap 1756	Feb.	18	13	48	0 8 ND	Sun	
	Feb.	13	17	2	0 5 SA	Moon		Aug.	14	7	12	0 7 NA	Sun	
	Feb.	27	17	18	1 21 NA	Sun		1757	Jan.	23	19	6	0 38 SD	Moon
	July	25	20	50	1 9 ND	Sun			Feb.	7	1	2	0 41 SA	Sun
	Aug.	8	20	52	0 4 NA	Moon	July		19	11	53	0 30 ND	Moon	
	Aug.	24	9	28	1 26 SA	Sun	Aug.		3	10	45	0 49 NA	Sun	
Leap 1748	Jan.	18	15	25	0 40 SD	Sun	1758	Dec.	29	6	11	1 20 ND	Sun	
	Feb.	2	23	49	0 46 SA	Moon		Jan.	12	18	13	0 0 NA	Moon	
	July	13	22	50	0 4 ND	Sun		Jan.	27	16	37	1 23 SA	Sun	
	July	28	11	34	0 49 NA	Moon		June	23	20	55	1 5 SD	Sun	
1749	Jan.	7	7	17	0 2 NA	Sun	1759	July	9	4	44	0 15 SA	Moon	
	June	18	21	34	0 59 ND	Moon		Dec.	18	19	29	0 40 ND	Sun	
	July	3	0	31	0 15 SA	Sun		Jan.	1	19	46	0 39 NA	Moon	
	Dec.	12	8	8	0 44 ND	Moon		June	13	5	23	0 1 SD	Sun	
1750	Dec.	27	21	12	0 13 SD	Sun	Leap 1760	Dec.	8	2	14	0 10 SA	Sun	
	June	8	9	9	0 15 SD	Moon		May	18	9	35	0 52 ND	Moon	
	June	22	6	51	0 58 SA	Sun		June	1	19	22	0 20 SD	Sun	
	Nov.	17	13	19	1 22 SD	Sun		Nov.	11	9	18	0 44 SD	Moon	
	Dec.	1	18	32	0 3 ND	Moon	Nov.	26	2	2	0 38 SA	Sun		
	Dec.	17	6	34	1 23 NA	Sun	1761	Apr.	23	5	40	1 24 SD	Sun	
1751	May	13	12	51	0 51 ND	Sun		May	7	10	2	0 11 ND	Moon	
	May	28	13	58	0 28 NA	Moon		May	22	13	24	1 9 NA	Sun	
	Nov.	6	12	43	0 44 SD	Sun		Oct.	16	10	29	1 27 ND	Sun	
	Nov.	21	9	47	0 39 SA	Moon		Oct.	31	23	43	0 2 SD	Moon	
Leap 1752	May	2	5	45	0 6 ND	Sun	Nov.	15	2	15	1 16 SA	Sun		
	Oct.	25	13	59	0 5 SD	Sun	<p><i>In this Table, the 1st Column expresses the Year—the 2d, the Day, Hour, and Minute—the 3d, the Moon's Latitude at the Middle of the Eclipse—and the 4th, the Luminary eclips'd.</i></p> <p><i>The Moon's Latitude is nearly the same on the Return of the same Eclipse, seldom differing more than a Minute or two.</i></p>							
1753	Apr.	6	6	20	0 45 SD	Moon								
	Apr.	21	19	37	0 39 SA	Sun								
	Sept.	30	21	36	0 41 ND	Moon								
	Cct.	14	21	59	0 11 NA	Sun								



# The Use of the foregoing TABLE.

**A** D D 18 Years, 10 or 11 Days, 7 Hours, and 43 Minutes to any *Eclipse* in the Table, and the Sum will be the *Return* of the *same Eclipse*.—If there be but 4 *Leap Years* in the 18 add 11 Days; if 5 *Leap Years* add only 10 Days.

In these *Calculations*, the Day is always suppos'd to begin at *Noon*; and end after 24 Hours, on the next day at *Noon*.—When the Day is in *December*, and the Addition of 10 or 11 Days makes it more than 31, then the *Overplus* must be reckon'd as so many Days in *January* in the following Year.—The same must be done with Respect to the Months.

Remember to add 11 Days more, for the Alteration of the *Style*, after *September 14th, 1752*.

An Example or two will make all plain,—By this *Table* it appears that the *Sun* was eclips'd

	D.	H.	M.	
1745 Sept. 14	5	20		Old Style.
18	11	7	43	
Add, because there are 4 <i>Leap Years</i> in the				
Gives first Return of that <i>Eclipse</i>	1763	Sept. 25	13	3
Add 11 Days for Alteration of the <i>Style</i>		11		
		Sept. 36	13	3
		30		
Deduct for the Month <i>September</i>				
Gives	1763	Oct. 6	13	3
Add, because there are 5 <i>Leap Years</i> in the next	18	10	7	43

The next Return of the same *Eclipse* 1781 Oct. 16 20 46 *New Style*.

Hence it is evident, that the *Sun* will be eclips'd *October 16<sup>d</sup> 20<sup>h</sup> 46<sup>m</sup>*; that is, the 17th Day at 3 Quarters past 8 o'Clock in the Morning.

From the same *Table* you may calculate *backwards*, or for Years past.--For, by only *subtracting* 18 Years, 10 or 11 Days, 7 Hours, and 43 Minutes from any *Eclipse* in it, you will have the Time when that *Eclipse* happen'd before.

Thus the <i>Sun</i> was eclips'd as above	1745	Sept. 14	5	20	Old Style.
Subtract, because there were 5 <i>Leap Years</i> in the	18	10	7	43	
Happen'd before in	1727	Sept. 3	21	37	
Subtract, because only 4 <i>Leap Years</i> in the	18	11	7	43	
Happen'd before	1709	Aug. 23	13	54	
Subtract, because 5 <i>Leap Years</i> in the	18	10	7	43	
Happen'd before	1691	Aug. 13	6	11	Old Style.

All these were great *Eclipses* of the *Sun*, somewhere upon the Earth, as the *Moon* was (you see in the Table) very near the *Southern Node* \*.

\* If the *Moon's Latitude* be less than 58 Min. the *Eclipse* will be *total* to some Part of the Earth: If more than 58, and less than 90, the *Eclipse* will be *partial* only: If more than 90 or 92, the *Sun* will not be eclips'd at all — To find its *Beginning* and *End*. From 8100 subtract the Square of the *Moon's Latitude*; the *Square Root* of that *Remainder*, divided by 31, will give *Half the Continuance* of the *Eclipse*, in *Hours* and *Minutes*; which added to, and subtracted from the *Middle*, found by this *Table*, will give you the Time it *begins* and *ends*, i. e. when the Shadow first touches the Earth, and when it last leaves it. This *Calculation* does not determine the *Beginning* and *End* to any particular Place, as *London*, &c. That requires another Method, and is difficult on Account of the *Moon's Parallax*.—The *Shadow* of the *Moon* travels, in solar *Eclipses*, over the Earth, at the Rate of about 36 Miles in a Minute.



In like Manner you may calculate an *Eclipse* of the *Moon*.

By this Table you see the <i>Moon</i> was eclips'd	D. H. M.
1744 Apr. 15 8 32 Old Style.	
Add, because there are only 4 Leap Years in the	18 11 7 43
Return of that <i>Eclipse</i>	1762 Apr. 26 16 15
Add 11 Days for the Alteration of the Style	11
	1762 May 7 16 15 New Style.

Hence we find that the *Moon* was eclips'd on *May* 8, about a Quarter past 4 o'Clock in the Morning; and that her upper Limb was immers'd in the lower Part of the *Earth's* Shadow, because she had about 35 Minutes of *South Latitude*.—If the *Latitude* of the *Moon* be less than 26 Minutes the *Eclipse* will be *total*: If more than 26, and less than 58 or 60, the *Eclipse* will be *partial* only: But if more than 60, there will happen *no Eclipse* at all.

To find the *Quantity*, or *Digits eclips'd*. — From 58 subtract the *Moon's Latitude*, multiply the Remainder by 6, and divide the Product by 16, so will the Quotient give the Digits sought.

To find (nearly) the *Beginning* and *End*. — From 3364 subtract the Square of the *Moon's Latitude*, the Square Root of that Remainder, divided by 31, will give the *Hours* and *Minutes* of *Half the Continuance*, which subtracted from, and added to the *Middle*, (found as above) you will have the *Beginning* and *End* of that *Eclipse* \*.

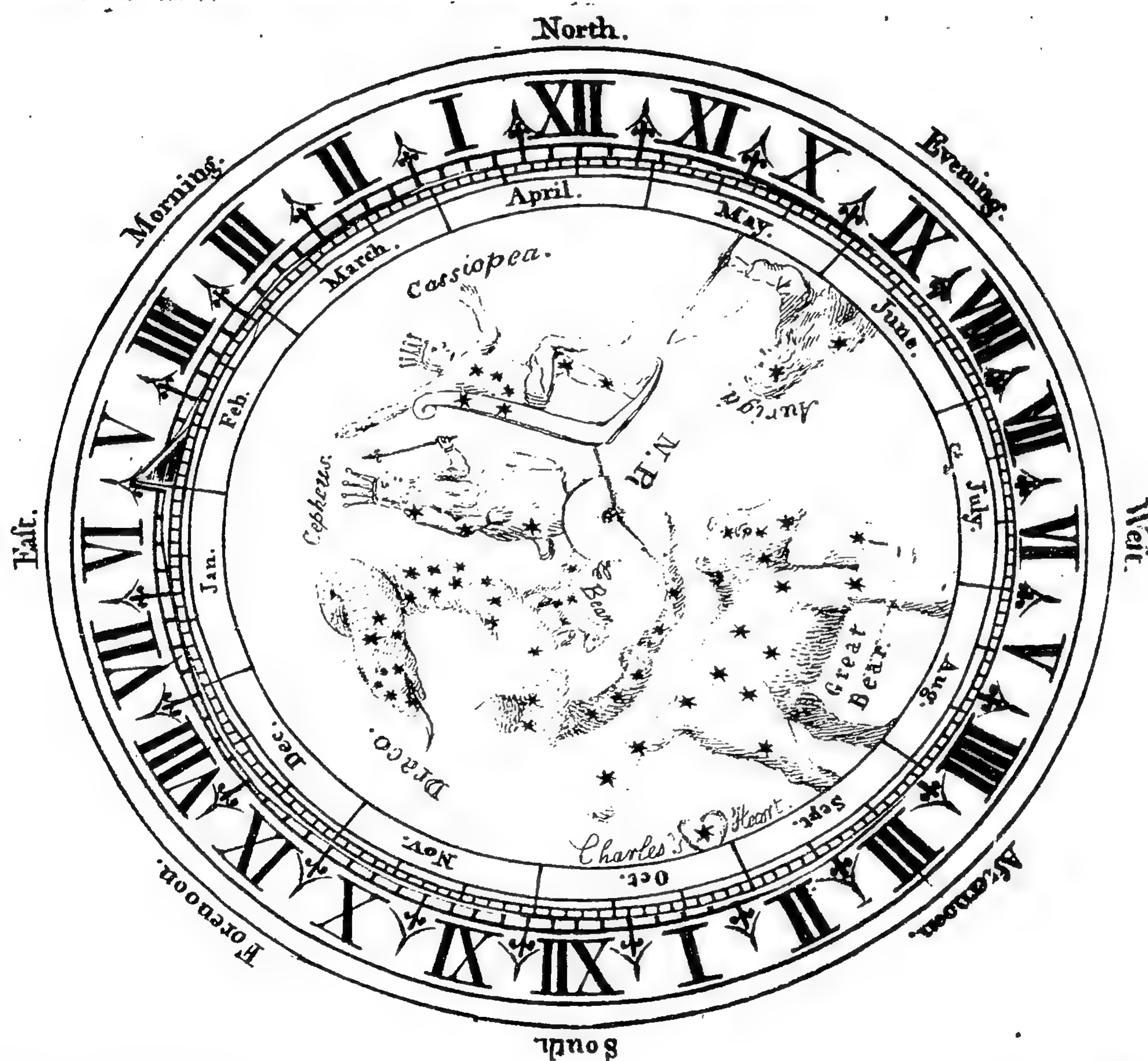
☞ These are the *Laws* which *GOD*, the great Former of the *Universe*, gave to the Heavenly Bodies at the Creation, which *Laws* are *constant*, *uniform*, and *regular* without Variation. To arrive to a perfect Knowledge of them is to arrive to the *Apex*, or Top of all *human Learning*. — What lofty—what exalted Ideas must we have of the *Deity*! his *Wisdom*, *Power*, and *Goodness*! when we view the *stupendous Canopy* of Heaven, and raise our Heads in Contemplation to that almost *infinite Extension* of the starry Firmament!—And when we are there, if we have liv'd good and pious Lives on this our *probationary Planet* below, our Souls want but a Step or two to penetrate into the *Abodes* of the *Blessed*, and be *happy for ever*.

\* The Reason of this Rule may be seen at Page 36 of my *Trigonometry*.



# THE DESCRIPTION AND USE OF THE ASTRONOMICAL CLOCK.

**T**HIS Instrument consists of two Parts, the one *fix'd*, the other *moveable*. The *fix'd* Part is a Circle divided into the 24 Hours of the Day. The upper XII stands for 12 at *Noon*, and the lower XII for 12 at *Midnight*.—The other Part is a *moveable* Circle, with such *Stars* and *Constellations* delineated in it as are near the North Pole, and never set in this part of the World. The Stars are bounded with the 12 Months, the Days of which are so adapted, as to stand against the Star, which comes to the South, or upper Part of the *Meridian*, with the *Sun*, at 12 o'Clock on those Days.



The *Use* of this Instrument is pleasant and easy. For, only hold up the Book, turning the Back of it towards the *North Pole*; then move the inner Circle about, till the Stars inserted therein lie in the same Situation with those you see in the Heavens; (as the *Great Bear*, commonly call'd *Charles's Wain*, the *Little Bear*, &c.) and against the Day of the Month you have the Hour of the Night.—Or, you may find the Hour of the Night by only stepping out, and observing what Star is on or near the *Meridian*, either above or below the Pole: Then set the same Star on the inner Circle to the same Position, and the Day of the Month will point the Hour of the Night, as before.



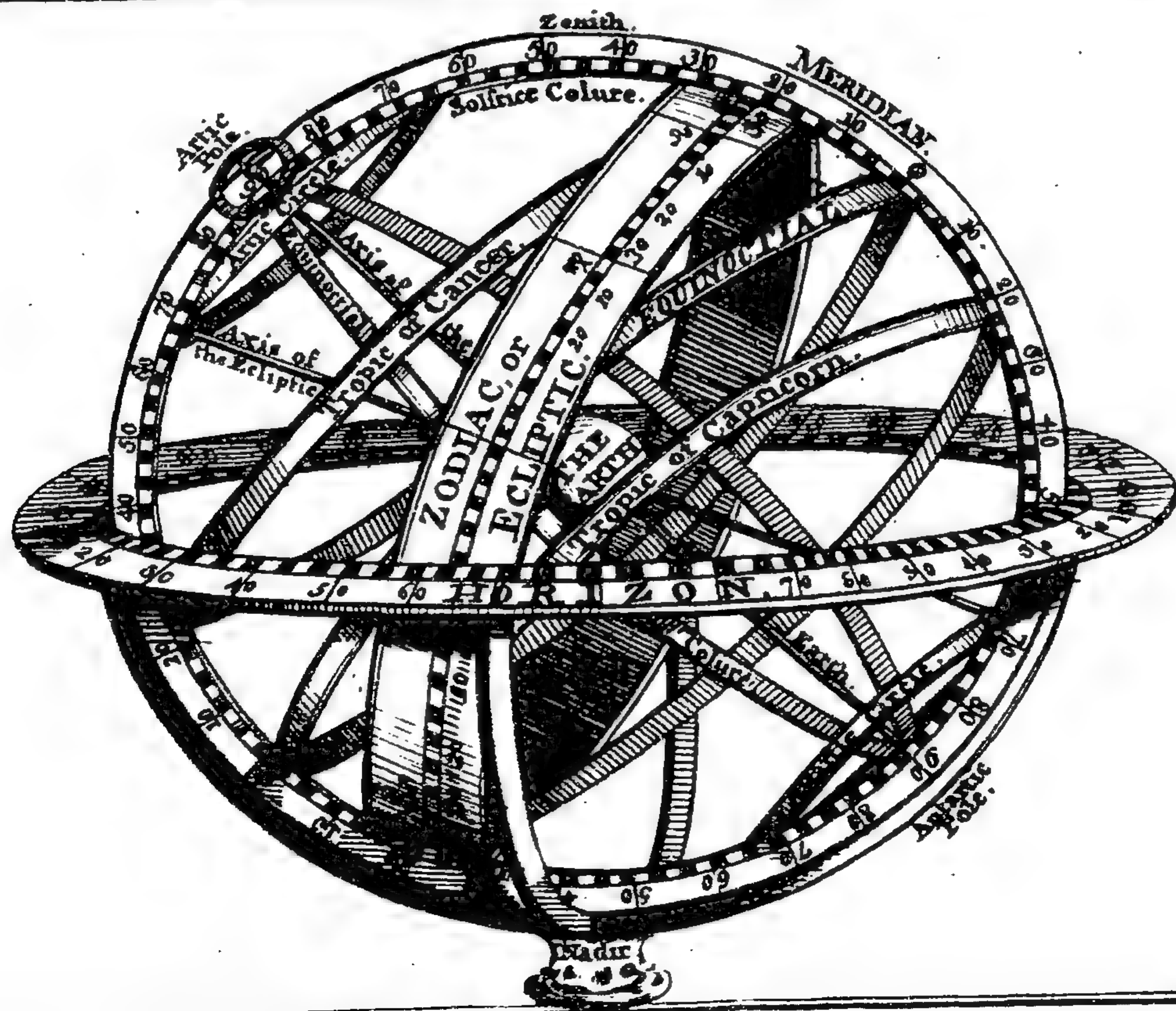
By this Instrument you may tell, at any Time, by Day or by Night, the Situation of those Stars when they are not visible, by Reason of the Sun's superior Light, or Clouds: For, having set the Day of the Month to the Hour, by your Watch, hold up the Book with its Back towards the North, (as in the last Example) and then the Stars upon the Clock will correspond with those in the Heavens, and point their Places there.

Thus, on the 23d of *August*, at 1 o'Clock in the Afternoon; I find the *Great Bear* full South; the two bright Stars in the Middle of his Back, call'd the *Pointers*, are upon the upper Part of the Meridian; the other two bright Stars, with the three in his Tail, lie a little to the East.—The *Little Bear*, and the *Dragon's Head*, full East.—*Cephus* and *Cassiopeia*, near the Meridian, below the Pole.—And *Auriga*, full West.

☞ This Clock will answer, at all Times, these *Problems* on this Side the *Equator*: But for those Places beyond it, in *South Latitude*, the *Constellations* round the *South Pole* should be inserted; and, in making the Observations, the Book should be held up, and turn'd towards the *South Pole*.



# THE COELESTIAL GLOBE AND SPHERE.





THE  
DESCRIPTION AND USE

OF THE  
CÆLESTIAL GLOBE.

THE *Cælestial Globe* is an *artificial Sphere*, on whose Surface the *fix'd Stars* are placed, at proportionable Distances from each other, just as they are in the Heavens; together with the principal Circles of the *Sphere*.—The Use of this curious Instrument is to point out the various Motions and Appearances of the *Sun*, *Moon*, *Planets*, and *Stars*, in an easy and natural Manner, without having Recourse to long and tedious Calculations.

The better to determine the Places of the Heavenly Bodies, the several Circles which are describ'd on the *Terrestrial Globe*, are imagin'd to be transferr'd to the Heavens, and delineated among the Stars, exactly over those Circles conceiv'd to be drawn on the Earth.——Thus, opposite the two *Poles* of the Earth are the two *Poles* in the Heavens; being the two places where the Earth's *Axis* (if continued thither) would seem to terminate among the Stars.—Over the *Equator* on the Earth runs the *Equinoctial* in the Heavens:—At  $23\frac{1}{2}$  Degrees on the North Side runs the *Tropic of Cancer*, and at  $23\frac{1}{2}$  South runs the *Tropic of Capricorn*.—At the same Distance from the *Poles* are the two *Polar Circles*, exactly over those on the Earth.—Besides these Circles, there is an *oblique one* going from one Tropic to another, cutting the *Equinoctial* in two opposite Places. This Circle is call'd the *ECLIPTIC*; and is that Path which the Earth would seem to describe among the Stars, in one Revolution, if it was beheld from the Sun. It is divided into 12 equal Parts, and each of these into 30 more, corresponding to the 12 Months of the Year; which 12 Parts are sometimes call'd the 12 *Signs*, from the Signs or Pictures drawn upon the Stars there\*.

Their *Names* and *Characters* are here express'd.

*Aries* ♈, *Taurus* ♉, *Gemini* ♊, *Cancer* ♋, *Leo* ♌, *Virgo* ♍,  
*Libra* ♎, *Scorpio* ♏, *Sagittarius* ♐, *Capricorn* ♑, *Aquarius* ♒, *Pisces* ♓.

The first *six* are call'd *Northern Signs*, as lying on the North Side of the *Equator*, and the last *six* *Southern Signs*, because they lye on the South Side the *Equator*.—On this Circle are found the *Sun's*, *Moon's*, and *Planets* Places; that is, under what *Degree* of any of these 12 Signs or *Constellations* they appear to be on any Day at Noon.

\* Sometimes these Circles are cut out, and put together in form of Rings, intersecting each other as they do in the Heavens, with a little Earth on the Axis in the Center: This serves to give a better Idea of the Position of each Circle than a long verbal Description would do. Their Names and Situations are express'd in the Figure under the Globe.



The Globe, thus delineated\*, is affix'd by its Poles to a *Brass Meridian*, graduated into four Quadrants, as that of the Terrestrial Globe is; (*i. e.*) on the upper Part from the Equator to the Poles; but on the under Part from the Poles to the Equator; and is then set in a *Wood Horizon*, on which are inscrib'd the 12 *Months*, and the 12 *Signs* of the *Zodiac*, the several Degrees of which being plac'd against the Days of the Month on which the Sun is found in that Part of the Heavens; and the 32 *Points* of the *Compass*. —To compleat the whole, there is added a *Quadrant of Altitude*, to be screw'd on occasionally to the Top of the Meridian. Also an *Hour Circle* round the North Pole, and an *Index*.

The Globe being thus fitted up, and the Learner having acquainted himself with the Position and Division of the several Circles and Constellations upon it, he may proceed, with Ease and Pleasure, to the Solution of the following

## P R O B L E M S.

### PROBLEM I. To find the *Sun's Place* in the *Ecliptic*.

Look the Day of the Month on the *Horizon*, and against it you have the *Sign* and *Degree* of the *Ecliptic* the Sun is in that Day: Then look the same *Sign* and *Degree* on the *Ecliptic Line* on the Globe, and there fix on a little *black Patch*, which will represent the Sun's true Place, and shew what Stars are round him that Day.

Thus, on the 24th of *May*, the Sun is in  $3\frac{1}{2}$  Degrees of *Gemini*, or the *Twins*:—Is situate near the *Bull's Eye* and the *Seven Stars*, which are not visible by Reason of his superior Light. But was the Sun to suffer a total Eclipse on that Day, you would then see those Stars shining near him very bright†.

### PROBLEM II. To find the *Sun's Declination*.

Having found the Sun's Place, (as in the last Problem) bring it to the *Brass Meridian*; and the Degree which stands over it, shows the *Sun's Declination*, or Distance from the Equator, either *Northwards* or *Southwards* at that Time.

Thus, on the 24th of *May*, you will find the Sun to have 21 Degrees of *North Declination*: But on the 12th of *December*, he is found to have  $23\frac{1}{4}$  Degrees of *South Declination*.

\* The *convex* Surface of the Globe corresponds with the *concave* Surface of the Heavens; whence it is easy to conceive, that, if *Holes* were made in each Star, and an *Eye* plac'd in the Center of the Globe, it would view, thro' those Holes, the same Stars in the Heavens represented by them.

† The Heavens are studded over with Stars as much by *Day* as by *Night*, only the greater Light of the *Sun* renders them invisible to us. But when that Luminary descends below the Horizon they begin gradually to appear. When the Sun is gone down about 12 Degrees, Stars of the first Magnitude become visible. When he is 13 Degrees below the Horizon, those of the second Magnitude are seen. When 14 Degrees, Stars of the third Magnitude appear. When 15 Degrees, those of the fourth Magnitude present themselves to view. When he is descended 16, 17, and 18 Degrees, Stars of the fifth and sixth Magnitude, with those of the smallest Size become conspicuous, and the azure Arch sparkles with all its Glory.



**PROBLEM III.** To *rectify the Globe*, or to adjust it so to the Place where you are, as it may represent the present State or Situation of the Heavens.

Raise the Pole, till it stands as many Degrees above the Horizon as is the Latitude of the Place you are in: which may be done by the Degrees mark'd on the lower Side of the Meridian, and number'd from the Pole: Fix the Quadrant of Altitude on the Meridian to the Zenith; that is, on the Top to the Latitude of the Place: Turn the Globe, by the Help of a Compass, till the Pole points to the real Pole of the World: Bring the *Sun's* Place in the *Ecliptic* to the Meridian, and set the Index to the upper 12; so will the Globe exhibit the Face of the Heavens for the Noon of that Day, at the Place you rectified the Globe for. And by turning the Globe till the Index points to any given Hour, you will see the Situation of the Heavens there at that Hour.

☞ If the Place be in *North Latitude*, the *North Pole* must be rais'd above the Horizon; if in *South Latitude*, the *South Pole* must be rais'd.

**PROBLEM IV.** To find the Time of the *Sun's Rising* and *Setting*; and also his *Amplitude*, or Distance from the *East* or *West* Points of the Horizon, at the Times of his Rising and Setting; and the Length of the *Day* and *Night*.

The Pole being elevated to the Latitude of the Place where you are, bring the *Sun's* Place in the *Ecliptic* to the Brass *Meridian*, and set the Index at the Pole to 12, or Noon: Then bring down the *Sun's* Place to the *Eastern* Side of the Horizon, and the Number of Degrees between the *East Point* and the Point where the Sun is, is the *Amplitude* at *Rising*. The Hour pointed to by the Index on the Dial-plate, is the Time of the *Sun's Rising*.—The *Sun's* Place brought to the *Western* Edge of the Horizon, shows there, in like Manner, the Amplitude at *Setting*; and the Index points out the Time of the *Sun's Setting*.

☞ The Time of the *Sun's Rising* being doubled gives the Length of the *Night*: And the Time of his *Setting* being doubled gives the Length of the *Day*, or the Time he appears above our Horizon.

Thus, on the 24th of *May*, at *London*, the Sun rises at 4, with 36 Degrees of *Eastern Amplitude* (i. e. 36 Degrees from the East to the North); and sets at 8, with 36 Degrees of *Western Amplitude*; making the Day 16 Hours long, and the Night 8 Hours.—The Sun now rises upon the North-East by East Point of the *Compass*, and sets upon the North-West by West Point.



PROBLEM V. To find the Beginning and End of *Twilight*.

Rectify the Globe; turn it *Westward*, with the Quadrant of Altitude, (which must be screw'd on the Meridian to the Latitude of the Place) till the *Point opposite* the Sun's Place in the *Ecliptic* cuts the Quadrant at 18 Degrees above the Horizon; the Index will then shew the Time *Twilight begins* in the Morning.—The same *Point*, brought with the Quadrant of Altitude to the *Eastern Side* the Globe, till it cuts the 18th Degree, as before, the Index will then point the Time when *Twilight ends* in the Evening\*.

Thus, on the 24th of *May*, you will find the Point in the *Ecliptic* opposite the Sun's Place, (which is  $3\frac{1}{2}$  Degrees of *Sagittarius*) will not reach the 18th Degree in the Quadrant of Altitude, which shows that the *Sun* does not descend, at that Time, 18 Degrees below the Horizon; consequently, we have then *no Night*, but a *continued Twilight*.—But, on the 12th of *December*, *Twilight* begins about Half past 5, and ends about Half past 6. And on the 21st of *March*, and 23d of *September*, *Twilight* begins about 4 in the Morning, and ends about 8 at Night.

PROBLEM VI. To find the *Azimuth* and *Altitude* of the *Sun* at any Time of the Day.

The Globe being rectified, and the Quadrant of Altitude screw'd on the Brass Meridian at the Latitude of the Place where you are, bring the Sun's Place to the Meridian, and set the Index to 12: Then turn the Globe, till the Index points the Hour given, and lay the Quadrant to the Sun's Place; so will the Degree of the Quadrant lying upon the Sun, be his *Altitude* above the Horizon: And the Number of Degrees counted on the Horizon from the South Point to the Point where the End of the Quadrant cuts it, will be his *Azimuth* at that Time.

Thus, on *May* 24, at 9 o'Clock in the Morning, you will find the Sun to have about 44 Degrees of *Altitude* above the Horizon; and  $62\frac{1}{2}$  of *Azimuth* from the South. And at 6 in the Evening of the same Day, his *Altitude* is 20 Degrees, and *Azimuth* 79 Degrees, so that the Sun is then upon the West by North Point of the *Compass*.

\* *Twilight* is that faint Light we have in a Morning before the Sun rises, and in the Evening after the Sun is set. This is found, by Observation, to begin when the Sun comes within 18 Degrees of the Horizon in the East, and to end when he is gone 18 Degrees below the Horizon in the West.—In the Southern Parts of *England*, the Inhabitants have no *real Night*, but a *Twilight*, from the 20th of *May* to the 22d of *July*.



**PROBLEM VII.** To find the *Oblique Ascension—Right Ascension—and Oblique Descension* of the Sun.

The Globe being rectify'd, and the Sun's Place brought to the *Eastern* Side of the Horizon; the Number of Degrees accounted from the Beginning of *Aries* to that Degree of the Equator now come to the Horizon, is the Sun's *Oblique Ascension*. The Sun's Place being brought to the Meridian, the Degree of the Equator lying under it is his *Right Ascension*. And, by bringing the Sun's Place to the *Western* Side of the Horizon, the Degree then of the Equator in the Horizon, is his *Oblique Descension*.

Thus, on the 24th of *May*, (the Sun being in  $3\frac{1}{2}$  Degrees of *Gemini*) his *Oblique Ascension* will be found to be 32 Degrees—his *Right Ascension* 62 Degrees—and his *Oblique Descension* 91 Degrees.

☞ The Difference in Degrees between the *Right* and *Oblique Ascension* turn'd into Time, by allowing 15 Degrees for every Hour, shows how much the Sun (at that Time) rises before or after 6 o'Clock. This is call'd the *Ascensional Difference*; which Difference is to be added to 6 in the *Summer Half-year*, but subtracted from 6 in the *Winter Half*, to give the Time of the *Sun's Rising*.—In the above *Example*, the *Ascensional Difference* is 30 Degrees (which in Time is 2 Hours) to be added to 6; consequently, the Sun rose that Morning at 4, and set at 8.

**PROBLEM VIII.** To find the *Right Ascension* and *Declination* of any *Star* represented on the Globe

Bring the *Star* to the Brass Meridian; observe the Degree which stands over it, for that is the *Declination*: and the Degree of the Equator which comes to the Meridian with the *Star* is its *Right Ascension*.

Thus you will find the *Declination* of *Aldebaran*, in *Taurus*, to be about 16 Degrees *North*; and the *Right Ascension* about 65 Degrees.—And, in like Manner, the *Declination* of *Syrius*, or the *Great Dog*, to be about  $16\frac{1}{2}$  Degrees *South*; and the *Right Ascension* about 98 Degrees.

☞ The *Right Ascension* and *Declination* of the *Sun* alter every Day; but the *Right Ascension* and *Declination* of the *fix'd Stars* continue the same throughout the Year.

PROBLEM



**PROBLEM IX.** To find the *Longitude* and *Latitude* of a *Star* or *Planet*.

Apply the End of the Degrees of the Quadrant of Altitude to that Pole of the Ecliptic which lies on the same Side the Ecliptic with the *Star*, and bring its graduated Edge to the *Star*, so will the Degree of the Quadrant at the *Star* point its *Latitude* reckon'd from the Ecliptic towards its Pole: And the Degree of the Ecliptic cut by the Quadrant, at that Time, will be the *Longitude* sought.

Thus, the *Latitude* of *Capella*, or the *Goat*, in the Left Shoulder of *Auriga*, is about  $22\frac{1}{2}$  Degrees *North*, and *Longitude* about 19 Degrees in *Gemini*.— And the *Latitude* of *Fomalhaut*, in the *Southern Fish*, is about 21 Degrees *South*, and *Longitude*  $29\frac{1}{2}$  Degrees in *Aquarius*.

☞ The *Latitude* of a *Star* is its Distance in Degrees and Minutes, counted from the Ecliptic Line towards its Pole.—If the *Star* lies on the North Side the Ecliptic, it has *North Latitude*; if on the South Side, it has *South Latitude*.

☞ The *Longitude* of a *Star* is its Distance from (the Equinoctial Point) *Aries*, reckon'd in Signs, Degrees, and Minutes.—If a *Star* is situate on the North Side the Ecliptic, you must apply the Quadrant to the North Pole of the Ecliptic, but if on the South Side, you must apply the Quadrant to the South Pole of the Ecliptic, as was done in the above Example of *Fomalhaut*.

**PROBLEM X.** To find the *Oblique Ascension* and *Oblique Descension* of any *Star*.

Elevate the Globe to the Latitude of the Place where you are; then bring the *Star* to the Eastern Side of the Horizon; and the Degree of the Equator then cut by the Horizon is the *Oblique Ascension*: Turn the *Star* to the Western Side, and the Degree of the Equator cut by the Horizon is the *Star's Oblique Descension*.

Thus at *London* you will find the *Oblique Ascension* of *Aldebaran*, or the *Bull's Eye*, to be about  $43\frac{1}{2}$  Degrees; and the *Oblique Descension* about 87 Degrees, —In like Manner, the *Oblique Ascension* of *Syrius*, or the *Great Dog*, will be found to be about 121 Degrees, and the *Oblique Descension* about 75 Degrees.

☞ The *Sun's* and *Planets Oblique Ascension* and *Descension* differ every Day in the same Latitude, but a *fix'd Star's Oblique Ascension* and *Descension* are every Day the same all the Year.

PROBLEM



**PROBLEM XI.** To find the *Rising*, *Southing*, and *Setting* of any *Star*, together with its *Continuance* above the *Horizon*.

Rectify the *Globe* for the *Place* where you are; bring the *Sun's Place* to the *Meridian*, and set the *Index* to the upper 12: This being done, bring the *Star* you enquire after to the *Eastern Side* of the *Horizon*; and the *Index* will shew the *Hour* of its *Rising*.—Turn it on to the *Meridian*, you have (by the *Index*) the *Time* of its *Southing*.—And, by bringing it to the *Western Side* of the *Horizon*, the *Time* of its *Setting*.—The *Hours* on the *Dial-plate* from the *Rising* to *Setting*, shew the *Continuance* of the *Star* above the *Horizon*, and the remaining *Hours*, the *Time* the *Star* is *below*, or under the *Horizon*.

Thus, on *May 24*, at *London*, the *Star Aldebaran*, or the *Bull's Eye*, will be found to *rise* about three *Quarters* past 4 in the *Morning*; will come to the *Meridian* about *Noon*; and *set* about three *Quarters* past 7 in the *Evening*. It therefore continues above the *Horizon* 15 *Hours*, and below it 9 *Hours*.

☞ This *Star* is not visible at that *Season* of the *Year*, by Reason of its *Nearness* to the *Sun*.—But, on the 24th of *November*, at *London*, *Aldebaran* will *rise* about three *Quarters* past 4 in the *Evening*, and *set* about three *Quarters* past 7 in the *Morning*; so that he will be then visible *all Night*, if the *Sky* continues clear.

**PROBLEM XII.** To find the *Eastern* and *Western Amplitude* of a *Star*.

The *Globe* being rectify'd, as before, and the *Star* brought to the *Eastern Side* of the *Horizon*, you have, upon the *Horizon*, the *Amplitude*, i. e. the *Distance* in *Degrees* from the *East*, either *Northward* or *Southward*; and also, the *Point* of the *Compass* the *Star* rises upon. Turn the *Star* to the *West Side*, and the *Horizon* shews the *Amplitude* and *Point* it sets upon there.

Thus, on the 24th of *May*, at *London*, *Aldebaran* will have about  $25\frac{1}{2}$  *Degrees* of *Amplitude* from the *East* towards the *North* at *Rising*; and about  $25\frac{1}{2}$  *Degrees* of *Amplitude* from the *West* towards the *North* at *Setting*.—He *rises* nearly *East-North-East*, and *sets* nearly *West-North-West*.

☞ The *Stars*, though they *rise* at different *Hours* of the *Day*, yet always *rise* on the *same Point* of the *Compass*.



**PROBLEM XIII.** To find the *Altitude* and *Azimuth* of a *Star* at any *Hour*.

The *Globe* being rectify'd, and the *Quadrant* of *Altitude* screw'd on the *Meridian* at the *Latitude* where you are: Bring the *Sun's Place* to the *Meridian*, set the *Index* to 12, and turn the *Globe* till the *Index* Points the *Hour* given: Then by laying the *Edge* of the *Quadrant* upon the *Star*, you find (by the *Degree* against it) the *Altitude* above the *Horizon* at that *Time*; and the *End* of the *Quadrant* will shew, upon the *Horizon*, the *Azimuth* of the *Star*, and also, the *Point* of the *Compass* it then bears upon from you.

Thus, at *London*, on *November 24*, at 9 at *Night*, you will find, (by proceeding as above) that *Aldebaran* will have about  $36\frac{1}{2}$  *Degrees* of *Altitude*; with 68 *Degrees* of *Azimuth* from the *South*; and that he bears upon the *East-South-East* *Point* of the *Compass*.—But, at 3 in the *Morning*, he will have about 41 *Degrees* of *Altitude*; about 59 *Degrees* of *Azimuth*; and bear upon the *South-West* by *West* *Point* of the *Compass*, nearly.

**PROBLEM XIV.** The *Altitude* of the *Sun* by *Day*, or of any *Star* by *Night*, being given, to find the *Hour* of the *Day* or *Night*.

Rectify the *Globe* to the *Place* where you are; fix on the *Quadrant* of *Altitude* to the *Meridian* at the *Latitude* given; bring the *Sun's Place*, at that *Time*, to the *Meridian*, and set the *Index* to 12. This done, turn the *Globe* and the *Quadrant* together, till the *Star*, or the *Degree* of the *Ecliptic* the *Sun* is then in, cuts the *Quadrant* in the *Altitude* given; the *Index* will then point the *Hour* sought.

Thus, on *May 24*, at *London*, when the *Sun* is observ'd to be about 44 *Degrees* high, in the *Morning*, you will find the *Time* to be 9 o'Clock. And when his *Altitude* is 20 *Degrees*, in the *Afternoon*, you will find it to be 6 at *Night*.—Also, on *November 24th*, at *Night*, *Aldebaran* being observ'd to be about  $36\frac{1}{2}$  *Degrees* high, and to the *East* of the *Meridian*, we find (by proceeding as before) that it was 9 o'Clock when that *Observation* was made.

**PROBLEM XV.** To measure the *Distance*, in *Degrees*, between any two *Stars*.

Lay the *Beginning* of the *Quadrant* of *Altitude* upon one of the *Stars*; apply the graduated *Edge* to the other; and the *Degrees* contain'd between the *Stars* are their *Distance* requir'd.

Thus the *Distance* between *Aldebaran* and *Capella* will be found to be 30 *Degrees*. And the *Distance* from *Syrius* (the *Great Dog*) to *Deneb* (the *Lion's Tail*) 81 *Degrees*.

☞ The same might have been done with a *Pair* of *Dividers*; for opening from one *Star* to another, and applying the *Wideness* to the *Equinoctial*, the *Degrees* between the *Legs* is the *Distance*, as before. If the *Quadrant* is not long enough to reach from one *Star* to the other at once, you may measure the *Distance* at twice.

PROBLEM



**PROBLEM XVI.** To find what *Stars* never *rise* nor *set* to the Inhabitants of any given Place.

All those *Stars* towards the *North Pole*, which lie not further from it than the *Zenith*, or Complement of the Latitude of the Place, never *set* at that Place.—And all those *Stars* which lie at the same Distance from the *South Pole* never *rise*, or appear above the Horizon of that Place.

Thus, at *London*, if you elevate the Pole to the Latitude of  $51\frac{1}{2}$  Degrees, you will see, by turning the Globe round, that all the Stars from that Latitude to the North Pole, as the *Great Bear*, *Little Bear*, *Draco*, *Cephus*, and *Cassiopeia*, never *set*, or descend below the Horizon.—As also, that those Stars situate at the same Distance from the South Pole, as *Hydrus*, *Toucan*, *Indus*, *Pavo*, *South Triangle*, *Musca*, *Crofters*, *Pisces volans*, &c. never ascend above the Horizon of *London*, but remain ever invisible to the Inhabitants there.

Hence it is easy to conceive, that the Inhabitants at the *North Pole* can never see any of the Stars lying South of the Equinoctial; nor can the Inhabitants at the *South Pole* see any Stars lying North of the Equinoctial. But those who *inhabit at the Equinoctial* will have the Pleasure of seeing all the Stars from Pole to Pole.

**PROBLEM XVII.** To *distinguish* the *Stars* in the *Heavens* one from another, and to know them by their proper Names.

Rectify the Globe to the Latitude of the Place where you are; bring the Sun's Place to the Meridian, and set the Index to 12: Then turn the Globe to the *given Hour*, and there let it remain; so will every Star inscrib'd upon it exactly correspond with, and point to the same Star in the Heavens; and by transferring the Eye from the Globe to the Stars, you will evidently discover the same there \*,

Thus, on the 24th of *November*, at 10 at Night, (the Globe being rectify'd, and plac'd, by means of a *Compass*, *North* and *South*) you will immediately perceive the *North Pole* of the Globe point to a *Star* of the *second Magnitude*, which is the *Pole-star*; round which all the rest circulate every 24 Hours.—At the same Time you may observe, a little lower, *two Stars*, not quite so bright as the *Pole-star*, almost in a Right-Line with it, and *four* more which form a Kind of *Quadrangle*: These seven make the Constellation call'd the *Little Bear*, the *Pole-star* being in the End of the *Tail*.——Near the same Place, but more towards the *East*, you may observe seven bright Stars, all of the second Magnitude, which are commonly call'd *Charles's Wain*, but by *Astronomers* the *Great Bear*; the two foremost of the Square lie almost in a Right-line with the *Pole-star*, and are called the *Guards*, or *Pointers*; so that

\* If a Right Line be imagin'd to proceed from the Center of the Globe, (when rectify'd) through any Star on its Surface, that Line will fall upon the same Star in the Heavens, and point it out, if continued thither.



knowing the *Pointers*, you may easily find the *Pole-star*.——Further on, almost *East*, and near the *Horizon*, is seen a bright Star of the first Magnitude, call'd *Procyon*, or the *Little Dog*.——Higher up the *Sky*, and a little more to the *North*, you find two bright Stars in *Gemini*, or the *Twins*; the uppermost is of the first Magnitude, call'd *Castor*, the other of the second Magnitude, and call'd *Pollux*.——Higher, still towards the *Zenith*, you see the brilliant Star *Capella*, or the *Goat*, in the *Shoulder* of *Auriga*; this is of the first Magnitude.——Lower down, and nearly *South-East*, you observe *Aldebaran*, or the *Bull's Eye*, a Star of the first Magnitude, and near that the *Pleiades*, or noted *Seven Stars* (all small ones) in the *Back* of the *Bull*.——Between *Taurus*, or the *Bull*, and the *Horizon*, is seen the glorious Constellation *Orion*, with two bright Stars of the first Magnitude; one in his *Right Shoulder*, call'd *Bed-elguezze*, the other in his *Left Heel*, call'd *Regel*: In the *Middle* of this Constellation are three Stars of the second Magnitude in a *Right-line*, and a little lower, three others of the third Magnitude, lying also in a *strait Line* with each other; which Stars, by the *Country People*, are call'd the *Ell* and the *Yard*, but by *Astronomers*, *Orion's Belt* and *Sword*.

In this Manner the rest of the Stars, in any other Constellation may be readily found, by observing how they lie with respect to those already known. A little Practice will make you well acquainted with them all.

Between the *Bull's Eye* and the *Seven Stars*, you observe a large Star of a heavy dull Colour; but upon the *Globe* you don't find any, in that Place, corresponding with it. This shews that Star to be one of the *Planets*; and, by looking into *Mr. White's Ephemeris*, you will perceive it must be *Saturn*: For, *Saturn*, at that Time, is in about 2 Degrees of *Gemini*, with about 2 Degrees of *South Latitude*, which Situation exactly agrees with that Part of the *Heavens* where you see him.

PROBLEM XVIII. To find all those Stars, which at any Hour, are *Rising*, *Setting*, or upon the *Meridian*.

Having rectify'd the *Globe*, as in the last Problem, turn it till the *Index* points the given Hour: The *Globe* being kept in that Position, all those Stars in the *Eastern Edge* of the *Horizon* are then *Rising*, those under the *Brass Meridian* are upon the *Meridian* in the *Heavens*; and those on the *Western Edge* of the *Horizon* are *setting*.

Thus, on the 24th of *November*, at 10 at Night, we find *Charles's Heart*, the *Lion's Head*, and *Syrius*, or the *Great Dog*, *rising*.—The *Little Bear*, *Perseus*, the *Ram*, and *Whale*, upon, or near the *Meridian*.---And *Aquarius*, or *Water-bearer*, the *Eagle*, *Hercules*, &c. *setting*.

PROBLEM



**PROBLEM XIX.** To find the *Place* of any *Planet* upon the *Globe*; and, by that Means, its true Situation in the Heavens.

First, by some *Ephemeris*, (Mr. *White's* is one of the best) which has the *Planets Places* calculated to every Day at Noon, find the *Longitude* and *Latitude* of that *Planet*: Then make a Mark with a Pencil, or stick a little black Patch in that Point on the *Globe*, which Point will show its true Situation, with respect to the *Stars*, and also what *Stars* immediately accompany it.

Thus, November 24, 1765, I find, by Mr. *White's Ephemeris*, that *Saturn* is in about 2 Degrees of *Gemini*, with a little more than 2 Degrees of *South Latitude*, at which Place I fix on a little black Patch representing his Situation in the Heavens.—The same Day, I find *Jupiter* to be in  $22\frac{1}{4}$  Degrees of *Leo*, with three Quarters of a Degree of *North Latitude*, where I stick on another Patch, for his true Place.—In like Manner you may set on little Patches representing all the *Planets*, which will shew you their true Places at that Time, and how they are situate with respect to the *Stars*, and to one another.

**PROBLEM XX.** To find when any of the *Planets* rise or set, or come to the *Meridian*; as also, the Point of the *Compass* they rise or set upon.

Rectify the *Globe* to the Latitude where you are; bring the Sun's Place to the *Meridian*, and set the Index to the upper 12, and the *Globe* will exhibit the exact Situation of the Heavens at Noon that Day. Then bring the little Mark representing the *Planet* to the *Eastern Side* of the *Horizon*, and the Index will point the Hour of its *Rising*: Turning it on to the *Meridian*, you will see the Time of its *Southing*: And bringing it down to the *Western Side*, you see the Index point the Hour of its *Setting*.

Thus, November 24, 1765, *Saturn* rises nearly North-East by East, about a Quarter past 4 in the *Evening*;—comes to the *Meridian*, or *souths* about *Midnight*;—and sets, nearly North-West by West, about Half past 7 next Morning. ——— *Jupiter* rises, East-North-East, about a Quarter past 10 at *Night*;—comes to the *Meridian* at Half past 5 next *Morning*;—and sets, West-North-West, at 1 in the *Afternoon*. After this Manner, may the *Rising*, *Setting*, &c. of the rest of the *Planets* be found.

☞ The *Azimuth*, *Altitude*, and *Declination* of the *Planets*, and also their *Amplitudes* at *Rising* and *Setting*, are found in the same Manner as those of the *Sun* and *Stars* delivered in the foregoing *Problems*.



PROBLEM XXI. To find the Course of a *Comet*, and also the Position and Direction of its *Tail* in the Heavens; with its *Rising*, *Setting*, *Amplitude*, *Azimuth*, &c. at the Time whilst it continues in our Part of the *System*.

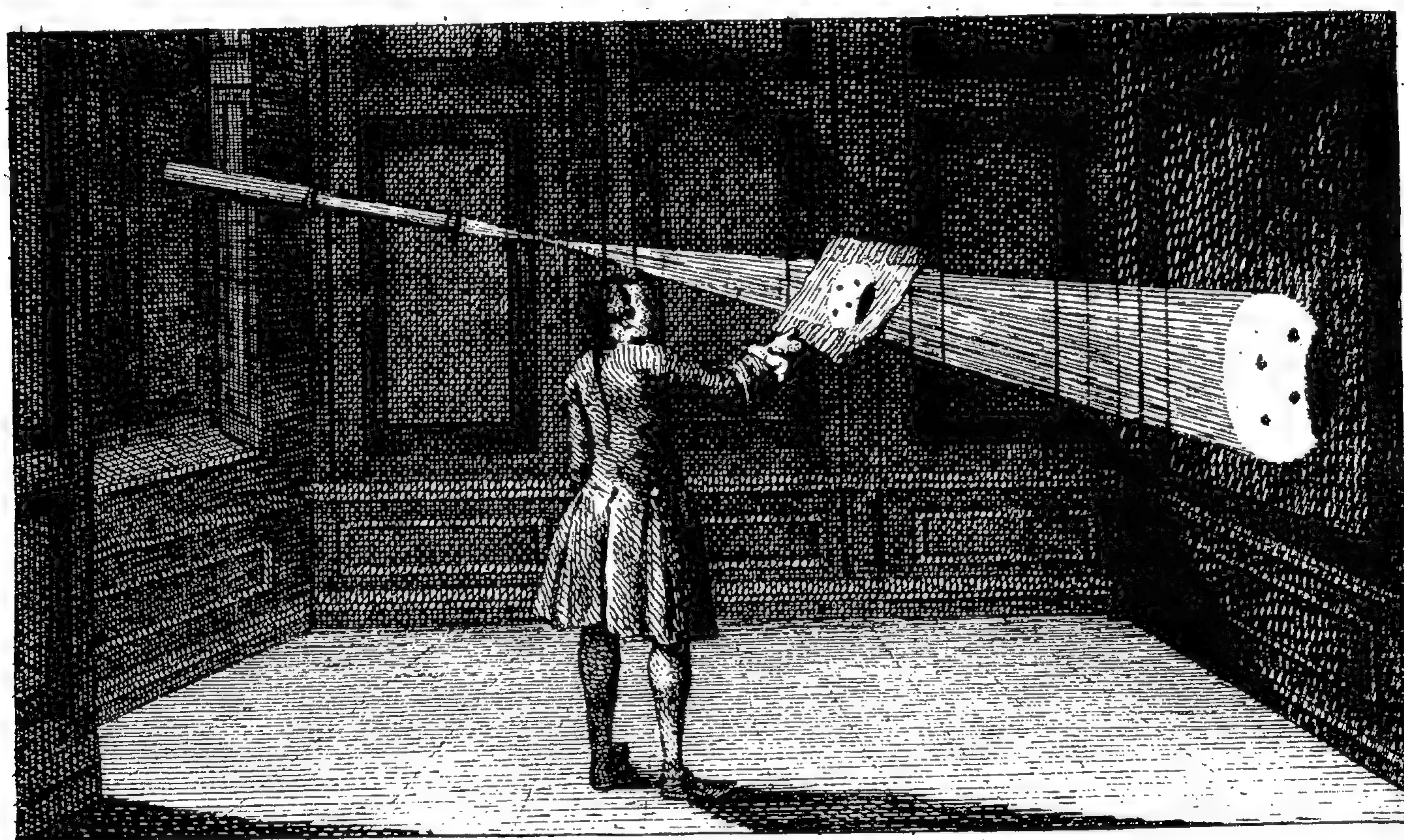
When a *Comet* is seen in our Hemisphere, observe its exact Situation with respect to the Stars about it, and likewise the Form and Length of its *Tail*, and stick a small Piece of Paper upon that Part of the Globe, cut into like Form with the *Comet*. Do so for *two* or *three* Nights successively, and set on like Patches, representing his Place at each Observation. By this Means you will discover its Course, which will be always in a great *Circle*, nearly: For, a *Thread* laid over these *Patches*, round the Globe, will exhibit the Tract it takes in the Heavens, and the Constellations it passes through.—Where the Thread cuts the *Ecliptic Line* will be the Place of its *Nodes*.

Now, if the Globe be rectify'd for the Day you make the Observation; the Sun's Place brought to the Meridian, and the Index set to 12; you may find the Time of the *Comet's Rising* or *Setting*, by bringing it to the *Eastern* and *Western* Side of the Horizon.—You may also find its *Azimuth*, *Amplitude*, *Altitude*, *Longitude*, *Latitude*, &c. (Position of its *Tail* with respect to the Horizon, at any Hour) in the same Manner as directed before for the *Stars*.



TO MAKE  
CURIOUS OBSERVATIONS  
UPON THE  
SUN, MOON, and ECLIPSES,  
In a DARKENED ROOM.

THE Room you make Choice of for Experiments of this Kind, must have a Window in it, which opens towards the Object you would observe: Let it also be made quite *dark*, by means of a Shutter plac'd before the Window. Then affix the *Object-end* of a *Telescope* of about 4 or 5 Feet in Length into a Hole made in the Shutter; draw out the other End to its usual Length, and turn it about till the Sun's Rays, passing thro' the Glass, fall upon a Sheet of white Paper held a little beyond the *Focus*, and you will have represented on the Paper, the exact Image of the *Sun*, as it really is in the Heavens, with the *Spots* distinct upon his Face at that Time, as appears in the Figure below.



If the Paper be remov'd further from the Glass, the Image will increase its Dimensions: And it may be so contriv'd, as to fall on the opposite Wall, (if it be cover'd with any thing white) where the Image will be magnified several *Feet*, and the *Spots* an *Inch*, or more, in Diameter.

The *Moon*, likewise, may be exhibited in this Manner, but her Light is rather too faint to render the *Spots* very distinct.

But, by this Method, an *Eclipse* of the *Sun* is seen to the greatest Advantage; For, without any Hurt or Uneasiness to the Eye, you behold the whole *Phænomenon* of the *Eclipse*.—How it *begins*, and where it *ends*;—in what Manner the *Moon* passes over the *Sun's Disk*;—with the *Quantity eclips'd* at every Moment, which is a most agreeable and delightful Appearance.

ASTRONOMICAL



# ASTRONOMICAL PARADOXES.

**H**AVING at the End of our *View of the Earth* inserted a few Propositions (which are generally call'd *Paradoxes*, from the Surprise or Fallacy they seem to carry with them at first Sight) purely to recall the Attention of the *young Geographer* to a Reflection on what he has been perusing; we have here added a few more for the Exercise of the *young Astronomer*; the Solution of which may be deduc'd from the Nature and Consideration of the *System*, deliver'd in the foregoing Pages.

**PARADOX I.** There are several Places upon the Globe of Earth, where the *Sun* and *Moon*, and all the *Planets* do actually *rise* and *set* according to their various Motions, but never any of the *fix'd Stars*.

**SOLUTION.** Under the *Poles*.—The *Planets* by their Revolutions in their Orbits are sometimes *North* and sometimes *South* of the Equinoctial Line; consequently, rise and set as the *Sun* does, with respect to those Places. But the *fix'd Stars* keeping an exact Distance from the Poles, may be said never to rise or set, but continually move round them.

✎ The Motion which the *fix'd Stars* have upon the Poles of the Ecliptic, being so very flow as to make no visible Alteration in their Places for Ages, cannot be any Objection to this Paradox.

**PARADOX II.** There is a very remarkable Place upon our Globe, where all the *Planets*, notwithstanding their different Motions and various Aspects, do all bear upon the same *Point* of the *Compass*.

**SOLUTION.** Under either of the *Poles*.—For to an Eye at the *North Pole* all the Stars, however situate, will bear upon the *South Point*: And, at the *South Pole*, they will, on the contrary, bear on the *North Point* of the Compass; because every Point of the Compass becomes a *Meridian*, as observ'd in Paradox I. in my *Geography*.

✎ For the same Reason, and at the same Places, a *Full-moon*, which is always opposite the *Sun*, may both happen to rise and set at the same Instant of Time, and upon the same Point of the Compass.

PARADOX



**PARADOX III.** There is a certain Place in the Island of *Great Britain*, where the *Stars* are always *visible*, (at any Time of the Day) if the Sky be not overcast with Clouds.

**SOLUTION.** The Place may be some deep Pit or Well; or Professer *Maske-line's* Observatory, at *Greenwich*; such also as *Tycho Brahe* had at *Denmark*, which was a deep Well beset with Glasses, where he sat and observed the *Stars* at all Seasons.

**PARADOX IV.** There is a certain Island near the Continent of *Europe*, some of whose Inhabitants are of such exquisite Sight, that even with *one* of their Eyes, they can actually behold 10 *Moons*, real and true, all at once above the Horizon; and also *ten Times* the Number of Stars beheld by others with both their Eyes at the same Instant.

**SOLUTION.** Any Island, or other Place; provided the Observer is furnish'd with a good *Telescope*, which will show the 5 *Moons* of *Saturn*, the 4 of *Jupiter*, and our own *Moon*; all which are 10 in Number. Also, they will see thro' the Glass, 10 Stars for 1 beheld by the naked Eyes. Nay, in the *Milky Way*, where we can't behold even one Star, they will see an infinite Number, so close and thick together, that their united, though faint Light causes that Whitishness, which gives it the Denomination of the *Milky Way*, before mentioned.

**PARADOX V.** To several Parts of the Globe, there are several *Planets* which are so far from coming to an *Opposition*, that they form neither *Square*, *Trine*, nor *Sextile Aspect* with the Sun.

**SOLUTION.** *Venus* and *Mercury*, whose Orbs are contain'd within the Orbit of our Earth, never form any of these Aspects with the Sun.

**PARADOX VI.** There are several *Planets* said to be in *Conjunction* with the Sun, not only when they appear in the *same* Degree of their Orbit with the Sun, but when they are in that Degree of their Orbit *diametrically* opposite to the former.

**SOLUTION.** The several Planets are *Venus* and *Mercury*, who have a *twofold* Conjunction with the Sun; one in the *superior*, and another in the *inferior*, or opposite Point of their Orbits. In the inferior Conjunction they pass like *Spots* between the Sun and us; but in the superior Conjunction they pass behind the Sun, leaving him between us and them.



**PARADOX VII.** There is *one* certain Place in the *Universe*, where the *Planets*, both inferior and superior, may be constantly seen to move forwards, in the same regular and uniform Manner, though, to most Places of the Earth, they appear (at the same Time) to move very unequally; and, sometimes, they seem to *run back*; and, at other Times, *not to move at all*.

**SOLUTION.** At the *Sun*, the Center of the System, the Planets move all regular and direct according to the Order of the Signs: But to us, out of the Center of their Orbits, they appear sometimes *direct*, sometimes *stationary*, and sometimes *retrograde*.

**PARADOX VIII.** Tho' the Number of Stars in a clear *Winter Night* seem almost *infinite*; and Mr. *Flamsteed* (late Astronomer Royal) has given us a *Catalogue* of 3000: yet it is difficult for the most penetrating Eye to reckon, at any Time, above 100.

**SOLUTION.** This Appearance is only a Deception of the Sight, arising from their vehement Twinkling, whilst we look on them confusedly, and without reducing them to order. For, when we come to view them more distinctly, we find the confus'd Number vanish, and we can seldom number more than in the whole Heavens.

☞ Tho' the Number of Stars which can be seen by the naked Eye are so few, yet it is probable there are many more beyond the Reach of our Sight. For, through *good Telescopes*, they appear in vast Multitudes in every Part of the Heavens; and the better the Glasses are the more are still discovered. The learned Dr. *Hook* has observ'd 78 Stars in the *Pleiades*, of which the naked Eye cannot discern more than 6. And in *Orion*, which has but 80 Stars in the *British Catalogue*, there has been counted more than 2000.

**PARADOX IX.** There is a certain place upon the Earth, above whose Horizon *Saturn* is 15 Years together; and there is another Place, of considerable Distance from the former, which has *Jupiter* nearly 6 Years above their Horizon, without once setting during that Time.

**SOLUTION.** This Place is under or near the *Poles*, where *Saturn* continues without setting all the Time he is in that Half of his Orbit, North of the Equinoctial, which is about 15 Years, his Period being 30 Years. The other Place, at a considerable Distance, is the *South Pole*, where *Jupiter* must continue visible through that Part of his Orbit South of the Equinoctial, which is about 6 Years; his Period being 12 Years nearly.

PARADOX



**PARADOX X.** There are several *Planets*, or *wandering Stars*, which at certain Times *appear* and *disappear*, whose Light decreases as they come *towards* the Earth, and increases as they go *from* the Earth; and so *transparent* are they, that the *smallest Star* can be seen through them.—There are, also, others, so *opaque*, that in Conjunction with the Sun they appear as *Spots* on his *Face*; and the *farther* they are from us, the *bigger* they seem.

**SOLUTION.** The first Part of this Paradox respects the *Comets*, which wander through all the Orbs of the *Planets*, and to vast Distances beyond *Saturn*, where they become invifible. These wonderful Bodies *decrease* in their Light as they come towards the Earth, (if they pafs between us and the Sun) and *increase* as they go from it, by turning more of their illuminated Side towards us. Thro' their amazing Tails, which are fo very rare and thin, Stars of the fmallest Magnitude may be feen. The other *opaque Planets*, which appear as *Spots* on the Sun's Face, are *Venus* and *Mercury*, in their inferior Conjunctions, paffing between us and the Sun. And the *Moon*, every one knows, appears much bigger in the *Horizon* than in the *Meridian*, though, in the latter Situation, ſhe is about 4000 Miles nearer us than in the former.

☞ This *Deception* is owing to the *Refraction* of the *Atmosphere*, as obſerv'd in one of the Paradoxes of my *Geography*.

To theſe Paradoxes Numbers might be added, but they would ſwell the Book beyond the Dimensions of a *Compendium*, as well as (perhaps) tire the Youth in the Peruſal. I ſhall therefore only beg Leave to detain him, whiſt I offer to his Attention an *Obſervation* on the beautiful and pious Exclamation of royal *David* on viewing the Heavens.

*When I behold* (ſays he) *the MOON and the STARS that Thou haſt ordained*, full of various Beings, whoſe Nature and Conſtitutions are admirably adapted to the World Thou haſt plac'd them in; who have ſtill, perhaps, retain'd their original Innocence and Purity; whoſe Hearts are now warm with Reflections on thy Goodneſs, and whoſe Tongues are telling forth thy Praiſes: *Lord, what is Man!*—Man, who has ſo often broken thy Laws, and ungratefully diſregarded thy holy Statutes, that *Thou art mindful of him!*—That thou doſt continue him ſtill in Exiſtence, and furniſh him ſo liberally with every Bleſſing of Life!—Or *what is the Son of Man*, the poor Inhabitant of this ſmall Corner of thy infinite Creation, that *Thou ſo regardeſt him!*—That Thou haſt, in ſuch a ſingular Manner, procur'd him a *REDEEMER*, who has ſo happily deliver'd *him* from the Miſeries juſtly due to his *Ingratitude*, and confer'd on him *Immortality* and *Glory* for ever.

\* \* \* The Learner having carefully gone over this System, will read Dr. *Keil's Lectures*, Dr. *Young's Astronomy*, and Mr. *Martin's Young Lady's and Gentleman's Philoſophy* with a peculiar Pleaſure.

F I N I S.



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